JOURNAL

OF THE

Association of Engineering Societies.

Boston, St. Louis, Chicago, Cleveland, Minneapolis, St. Paul, Kansas City, Helena.

TRANSACTIONS

Of the Boston Society of Civil Engineers, the Engineers' Club of St. Louis, the Western Society of Engineers, the Civil Engineers' Club of Cleveland, the Engineers' Club of Minnesota, the Civil Engineers' Society of St. Paul, the Engineers' Club of Kansas City, and the Montana Society of Civil Engineers.

VOLUME IX.

January, 1890, to December, 1890.

PUBLISHED BY

The Board of Managers of the Association of Engineering Societies

78 La Salle Street, Chicago.

Press of JOHN W. WESTON, C. E.,
Office: 78 La Salle St., Chicago.

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Volume IX., January 1890 to December 189 .

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ASSOCIATION OF ENGINEERING SOCIETIES.

ORGANIZED 1881.

Vol. IX. January, 1890. No. 1.

This Association, as a body, is not responsible for the subject matter of any Society, or for statements or opinions of any of its members.

EXPERIMENTS ON FLOW OF WATER THROUGH LARGE GATES AND OVER A WIDE CREST.

BY CHARLES E. HABERSTROH, MEMBER OF THE BOSTON SOCIETY OF CIVIL ENGINEERS.

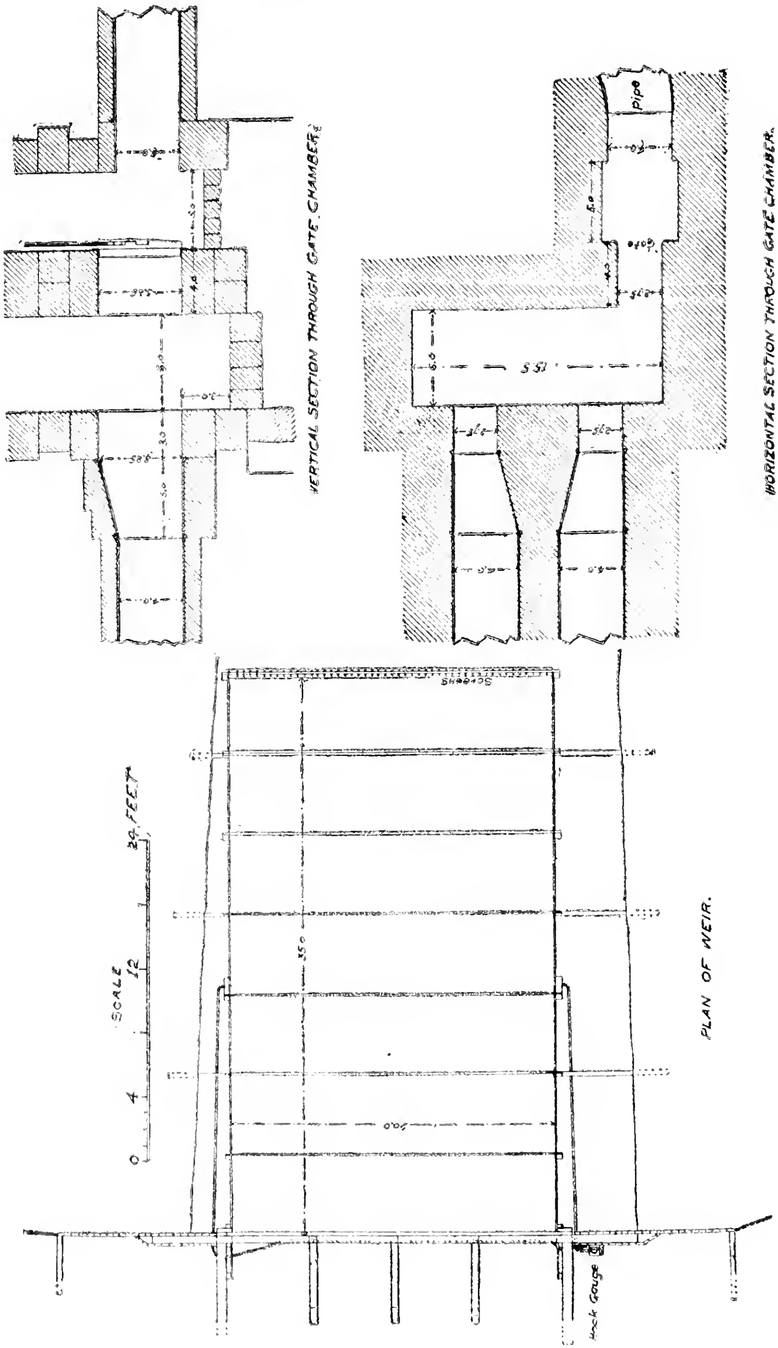
[Read May 15, 1889].

I made early in 1888, under the direction of Mr. Desmond FitzGerald weir measurement of the flow through the two iron waste gates at Dam 4 of the Boston Water Works, for various heights of openings, and also of the flow over the stone overfall of the waste-way and the lower set of flash-boards on overfall.

I will give a brief description of the gates, their location, etc., of the overfall and the weir used to measure the flow; also an account of the method of conducting the experiments and some of the results obtained.

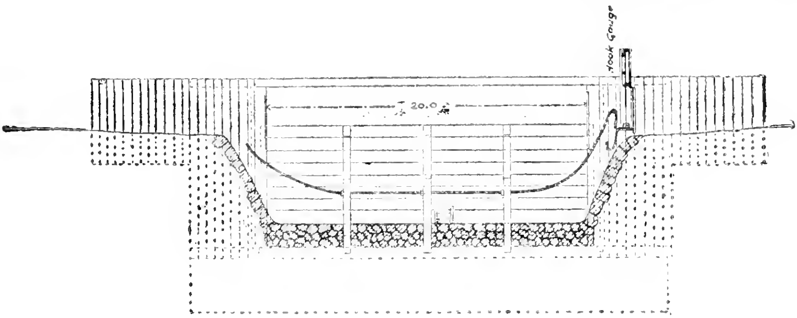
Reservoir No. 4 was formed by the construction of Dam 4 across the valley of Cold Spring Brook. When the surface of the water in the reservoir is at high-water mark, the water in front of the gate house is about 48 feet deep. The waste of water from the reservoir is controlled by two iron gates. The bottom of the opening of the lower gate is about 48 feet below high water, and of the upper gate about 25 feet. The water is conducted to the wells in front of the gates through 48-inch pipes, laid without any fall. The pipe leading to well in front of upper gate is 45 feet long, and of lower gate, 84½ feet. The opening in the masonry for each gate is 2.75 feet wide, 5.25 feet high and 4 feet long. The iron gates and frames are at the upstream end of the masonry openings. The opening in the upper gate frame is 2.513 feet wide and 4.921 feet high, and in the lower, 2.519 feet wide and 4.966 feet high. The gates are of a pattern similar to all the gates in use at the various gate houses of the Boston Water-Works, and have brass facings where the surfaces of the gate and frame press against each other.

The water, after passing either gate, enters a common chamber 15.5 feet long and 6 feet wide, and flows thence through two 48-inch pipes into Cold Spring Brook. A temporary weir was built across the brook, about 119 feet below the outlet of the two 48-inch pipes. It was desirable to measure as large a flow as possible; but it was found that

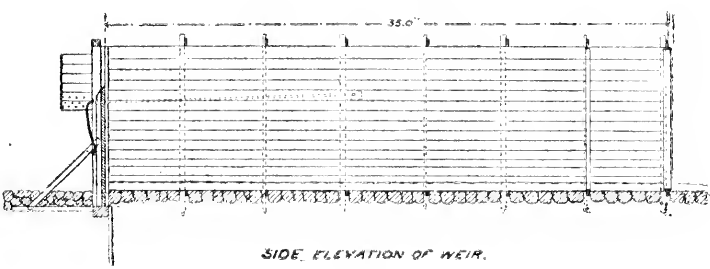


EXPERIMENTS ON FLOW OF WATER THROUGH GATES.—BOSTON WATER WORKS, 1888.

a weir 20 feet long and possessing a depth of 2 feet, which would gauge 120 million gallons, was the largest weir which could be built without incurring too much expense. The elevation of the weir was such that during the experiments the lower gate was submerged to its full height. The upper gate always had a free discharge. The weir was made from a three-inch thick hard pine plank, planed to present a sharp edge to the approaching current, and chamfered so the water after passing the edge could not touch it. The weir plank rested upon three-inch thick spruce stop-planks, which were placed on a heavy sill below the bottom of the brook. These stop-planks were planed to present a smooth surface to the current, and they were kept in position so their upstream sides were in



END ELEVATION OF WEIR.



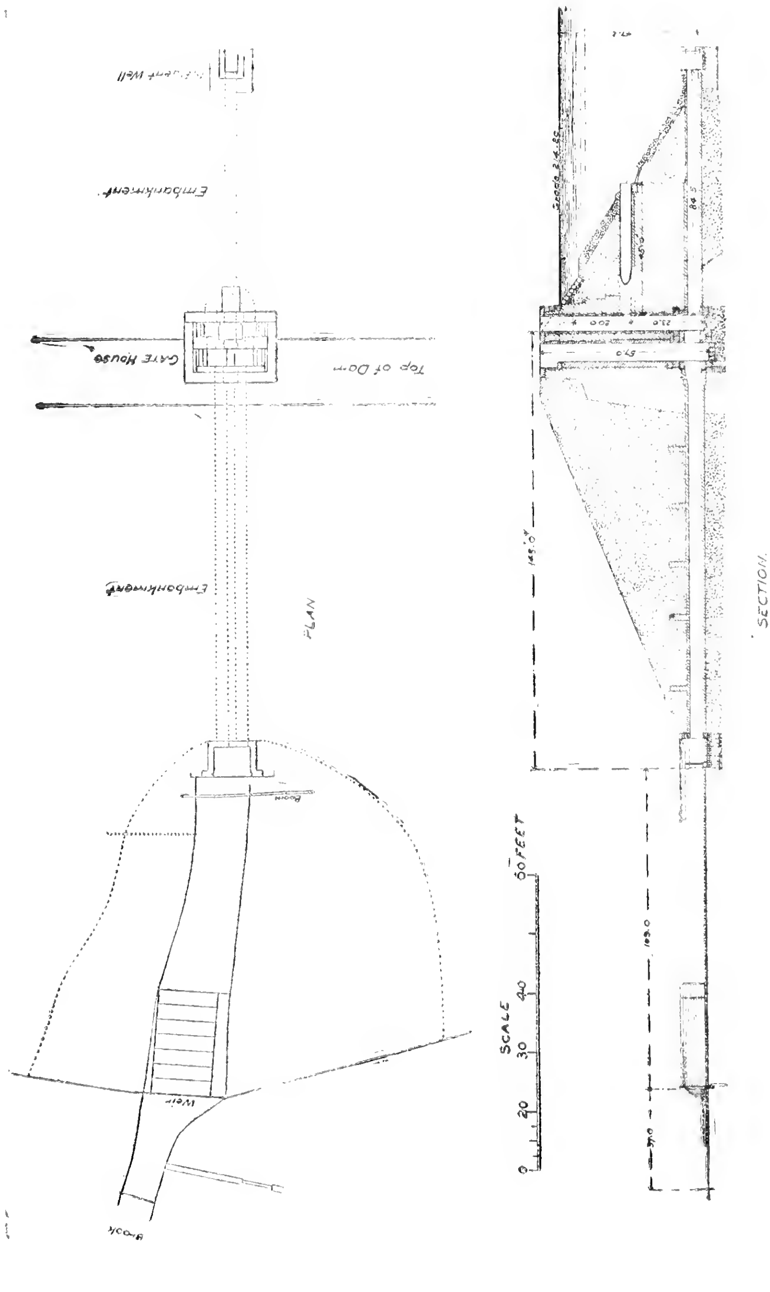
SIDE ELEVATION OF WEIR.

the same perpendicular plane, by upright joists placed against the lower face of the weir, and bolted to the sill and braced to keep them exactly perpendicular. The weir stop-plank was clamped to the upright joists to prevent any upward movement of the stop-planks. The channel of approach was 35 feet long, and as it was 20 feet wide, the length of the weir, there were no end contractions. The sides of the channel were made of matched pine boards planed smooth and having tight joints, so that no water could approach the weir without passing through entrance of channel. The bottom was of earth, level, and six feet below lip of weir. In order to have the flow steady and parallel to the sides of the channel, a screen was placed at the entrance and another five feet beyond. A stout screen was placed just beyond the outlet of the 48-inch pipes and also a boom, to

check the velocity of the issuing water. The depth of the water passing the weir was measured by a hook gauge of the same pattern used on the Sudbury-River experiments. The water was conveyed to the hook gauge pail by an iron pipe coupled to a short piece of rubber hose. This pipe was connected with the channel of approach 15 feet from and 0.4 foot below lip of weir. The pipe where it connected with the channel was perpendicular to it and its end flush with the side of channel. The gauge pail could also be connected in a similar manner with the opposite side of the channel of approach; and observations taken during the experiments showed the same depth passing the weir regardless of which side of the channel the gauge pail was connected. After all the woodwork connected with the weir had been wet long enough to allow for swelling, the lip of the weir was brought to a level. The level of the weir was tested and the zero of the hook gauge set with the edge of the weir by water levels, an apparatus similar to one used in the Sudbury-River experiments being used for that purpose.

The level of the weir was tested and compared wth the zero of the hook gauge at intervals during the experiments. The method of conducting the experiments was as follows: After the gate had been opened to any desired height and the flow over weir had become steady, gauge readings were taken every 30 seconds for 20 minutes. When the experiment was half finished, the elevations of the water in the basin, in the well in front of gate, in chamber below gate and at outlet of the 48-inch pipes, were taken by assistants. As each experiment occupied so short a time, and the storage reservoir held over five million gallons for each tenth of a foot, the change of head on the gates was very small, amounting to not over 0.04 foot for the largest flow, and one set of elevations taken at the middle of each experiment was deemed sufficient. As soon as the last gauge reading was taken, the opening of the gate was changed and the next experiment started as soon as flow over weir became steady, which usually took from 15 to 20 minutes. The experiment on each opening was usually repeated.

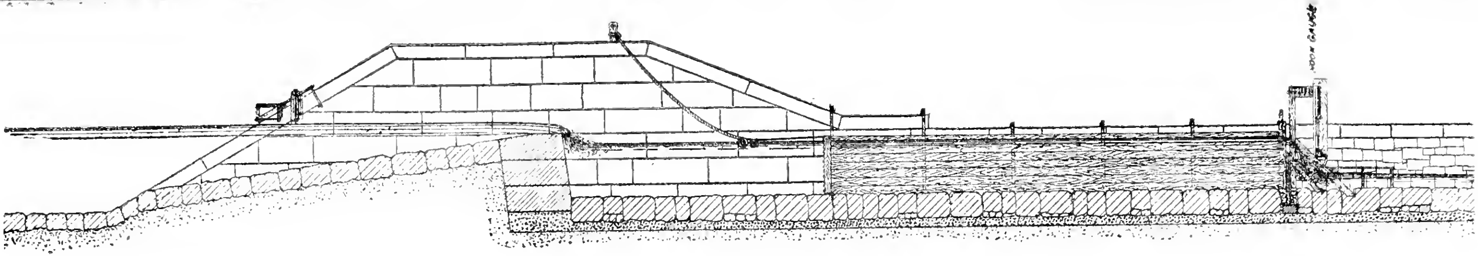
In calculating the results of the experiments, the depth on weir, as measured, was first corrected for velocity of approach by Messrs. Fteley and Stearn's formula: $C = ch$, in which C is the quantity to be added to the measured depth, and c a co-efficient of h, the head due to velocity of approach. The quantity flowing over the weir was then calculated by the formula: $Q = 3.31\ LH^{\frac{3}{2}} + 0.007\ L$. To obtain the flow through the gate, the above quantity was subject to a constant subtractive correction for each gate, due to the difference between a steady flow from a spring and leakage from the gates into the weir basin and leakage from weir basin. The leakage was measured by a small weir. The flow through gate, area of gate opening and head on opening being known, the coefficient of flow was obtained by solving for c in the formula $Q = \text{area} \times c \sqrt{2\,gh}$. The coefficients for each opening of the gate were then plotted and a curve of coefficients drawn. By examining the diagrams of the coefficients of the two gates, it will be seen that the two curves are similar, but that the coefficients of the lower or submerged gate are about six per cent. larger on an average than those of the upper



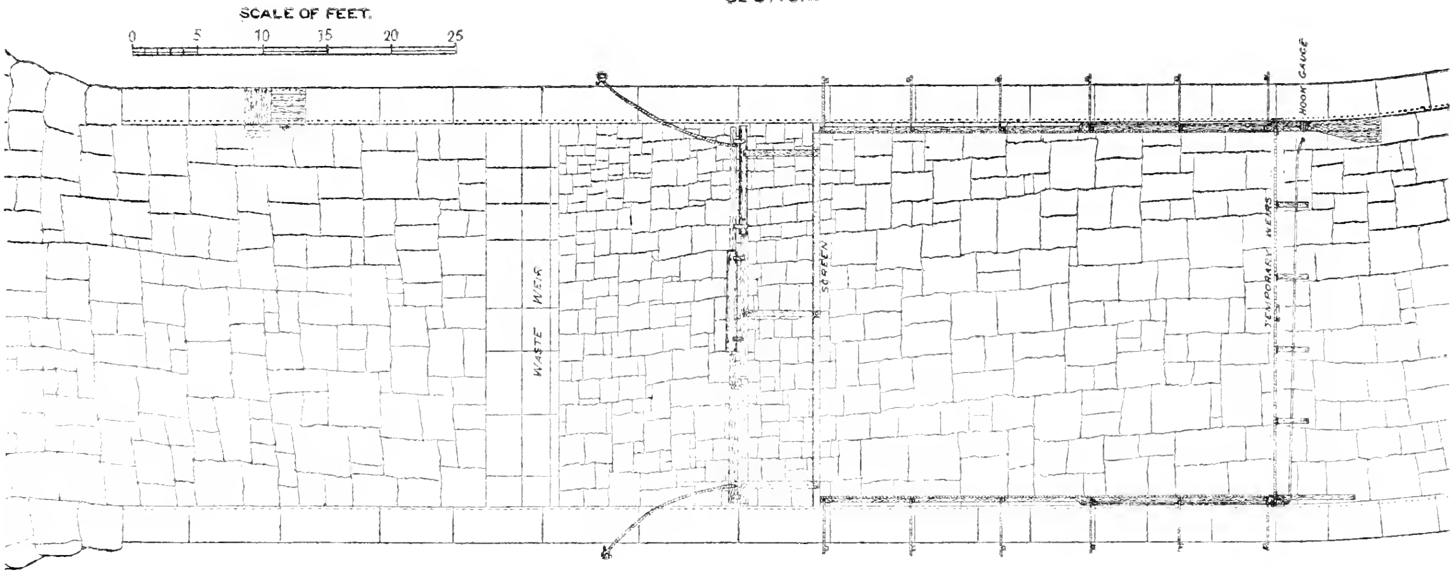
EXPERIMENTS ON FLOW OF WATER THROUGH GATES—BOSTON WATER WORKS 1888

gate. One peculiarity in the curve will be noticed. When the height of the opening in either gate reaches 0.42 foot, the coefficient suddenly increases. At this point the gates are entirely free from the beveled sockets into which they would be forced if lowered, and the increase in the coefficient is due to the sudden increase of the leakage or flow over the top of the gate. This was plainly seen during an observation on the flow through openings of the upper gate, up to the height. As far as I know there is no record of any previous measurements of the flow through gate openings as large as these. General Ellis measured at Holyoke the flow through openings as large as two feet square and two feet in diameter, but they were openings in quite thin iron plates planed smooth. These plates were fastened against a comparatively thin wooden bulkhead where the water had a chance to spread as soon as it passed the iron plate. The velocity of the current of water approaching the openings was inappreciable. The value of the coefficient of flow which he obtained was about 0.60. At Dam 4 the width of the well from end of 48-inch pipe leading from the basin to the gate is only five feet, and since the water issues from 48-inch pipe with a velocity varying from about 1.2 feet per second for ten millions to about 14.4 feet for largest flow measured, the velocity of approach to gate opening must have been quite large. This probably accounts in a large measure for the increased value of the coefficients of flow obtained.

The waste-way is near the extreme end of the dam and is 30 feet wide. The bottom is built with a slope of about eight to one, which commences just before it intersects the slopes of the sides of the waste-way, and is rough paving to within five feet of the edge of the overfall. Of the last 5 feet, the 2.75 feet, which is a continuation of the slope, is pointed granite, and the remaining 2.25 feet, the width of the level part of the overfall, is smooth hammered granite. The distance from the edge of the overfall to where the water in the basin, when at the level of the overfall, intersects side coping, is 25 feet, and to where the bottom slope intersects coping is 32 feet. The sides of the waste-way are built of quarry faced granite. There is a fall of 5 feet in the bottom of the waste-way at the overfall. The waste-way is then straight and perpendicular to the overfall for about 56 feet. It then commences to curve, and in a short distance to fall by a series of steps till it reaches Cold Spring Brook. The sides of the waste-way below overfall are about 5 feet high, and the bottom is made of large block paving laid in cement and resting on a bed of concrete. The weir was located at the end of the straight part of the waste-way, about 56 feet below overfall. It was 28 feet long, and the channel of approach, which was 28 feet wide and 36 feet long, had a depth of three feet below lip of weir. This depth allowed a depth of one foot to be gauged on the weir, and left fall of one foot from edge of overfall to surface of water. One screen at entrance of channel of approach was found sufficient, and a boom was located between overfall and screen to prevent waves from striking screen. The side of the channel of approach were calked at the bottom to prevent any water from approaching the weir without passing entrance of channel. The depth of the flow over overfall was measured by a point gauge which read zero when its point was on a level with edge of overfall. This gauge was near the west side

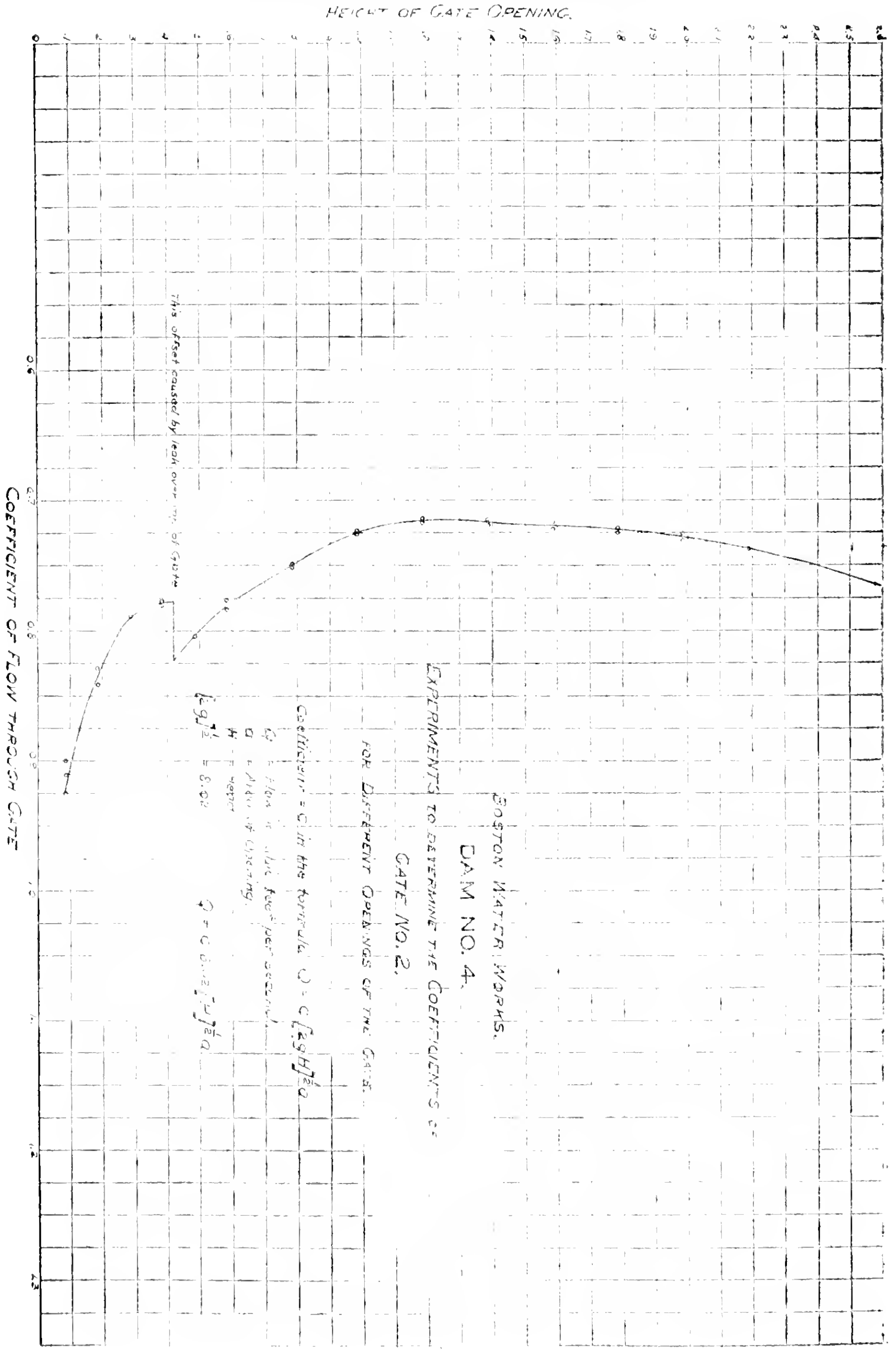


SECTION.

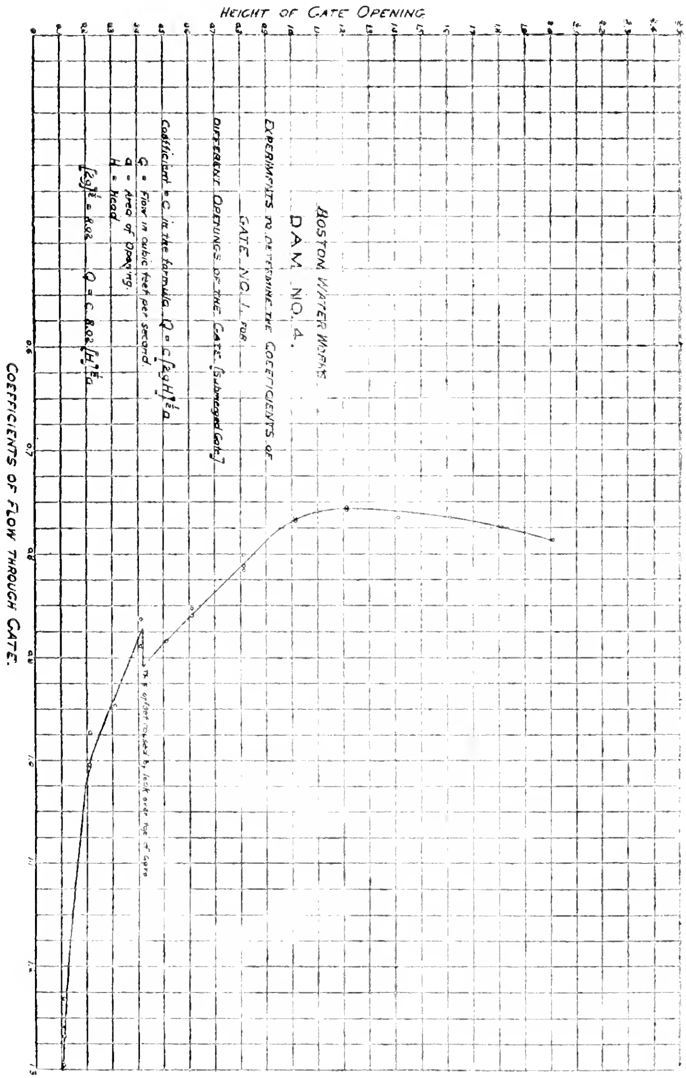


PLAN.

EXPERIMENTS ON FLOW OF WATER OVER WASTE WEIR—BOSTON WATER WORKS, 1888.

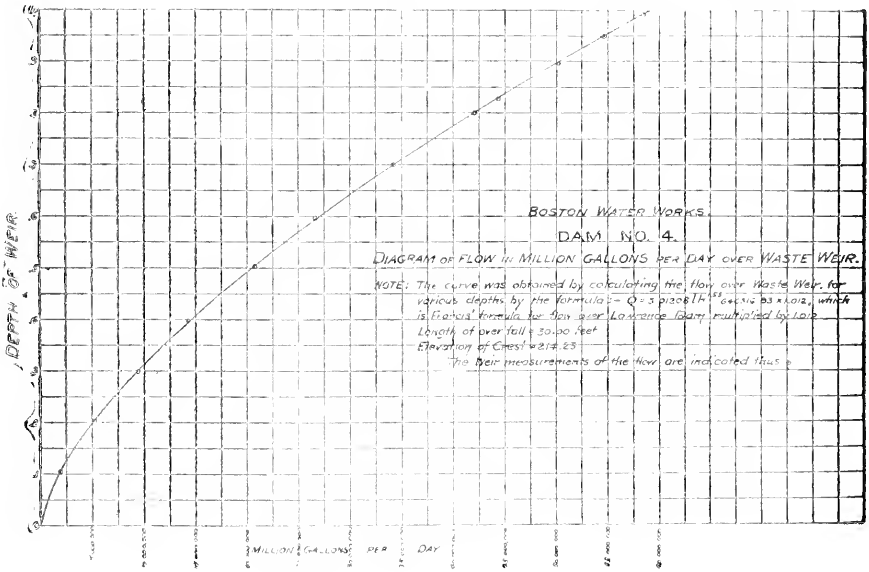

HEIGHT OF GATE OPENING.
COEFFICIENT OF FLOW THROUGH GATE
This offset caused by leak over top of Gate
BOSTON WATER WORKS.
DAM NO. 4.
EXPERIMENTS TO DETERMINE THE COEFFICIENTS OF
GATE NO. 2,
FOR DIFFERENT OPENINGS OF THE GATE.

of waste-way and 20.5 feet from edge of overfall. A boom was placed at the entrance of the waste-way to prevent any slight disturbance in water passing overfall. The location of pipe leading from



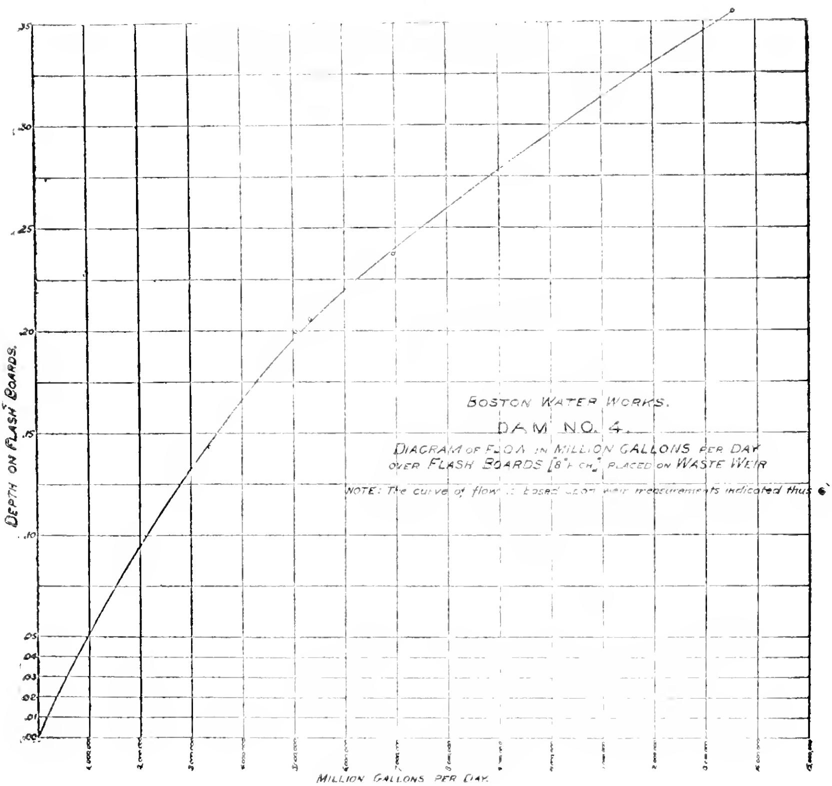
channel of approach to gauge pail, construction of weir and method of conducting the experiments, were similar to those of the weir already described. During an experiment, readings of the point guage were taken by an assistant every 30 seconds, at the

same time the weir gauge was read, the time being given by another assistant. The flow over the overfall was gauged for every tenth in depth as near as possible and the gauging repeated, though not on the same date. The observed depths on the weir were corrected for velocity of approach. The flows over overfall for different depths were calculated directly from the corresponding weir measurements. The quantities in million gallons per day corresponding to these depths were then plotted and a curve of flow drawn. It was found that Mr. Francis' formula for flow over Lawrence dam multiplied by the constant 1.012 or $Q = 3.01208 \times L.H.^{1.53} \times 646316.93 \times 1.012$ agreed with these experiments Mr. Francis' experiments were made over a wooden model 10 feet wide, having the same slope and width of crest as the Lawrence dam. The



flow was measured by a sharp edge weir placed below model. The channel of approach to model was 10 feet wide, the same width as the length of crest. Width of level crest = 2.95 feet, horizontal length of slope about 17 feet, height of slope about 6 feet, making slope about 3 to 1. Five experiments were made, and formula said not to be liable to error exceeding one per cent. for depths between 7 and 20 inches. The formula adopted for flow over Dam 1, which is built of the same materials, and dressed the same as the overfall at Dam 4, and has a slope of 3½ to 1, with a horizontal width of crest of 20 inches, was Mr. Francis' formula multiplied by the constant 1.03. The flow over overfall for every 0.05 foot difference in depth up to one foot was then calculated, and a curve of flow plotted. This curve is shown on the diagram of flow over overfall at Dam 1. The actual weir measurements are represented by the points in circles.

Two sets of flash-boards can be put in place on the overfall at Dam 4. The lower set is 8 inches high and the upper set 4 inches, making a total height of one foot. The elevation of the top of the upper set, when in place, is the same as high water in the basin. The flash-boards are held in place by two grooves cut in sides of waste-way, one on each side, and two movable iron flash-board grooves. These iron grooves are placed on the overfall so as to make the three lengths into which the flash-boards are divided



equal. The flash-boards are 3 inches wide for 6 inches each side of the centre, and then are chamfered to 2 inches in width at 6 inches from the ends. This chamfering was all done on one side of the flash-boards. When in place, the chamfered side faces the basin, and they are placed about 22 inches back from edge of overflow. The flow over lower set of flash-boards was gauged, and the resulting flows corresponding to various elevations of the basin plotted and a curve of flows drawn. The actual length of the flash-boards available for the passage of water, after deducting the width of the two iron grooves and the projections of the sides of the waste-way at the ends of the flash-boards, is 29.2 feet.

FACTS AND SPECULATIONS REGARDING THE PLANET MARS.

BY N. B. WOOD, MEMBER OF THE CIVIL ENGINEERS' CLUB OF CLEVELAND.

[Read November 26th, 1889.]

When, in the progress of enlightenment, man became acquainted with the real nature of sun, moon and stars, an uncontrollable and universal desire seemed to take possession of him to believe and demonstrate that all of these bodies were inhabited by human beings. He argued that an infinitely powerful and wise Creator would never have produced these stupendous globes, so like our earth, had he not intended them to be similarly inhabited. Sir William Herschel, in his imagination, peopled the sun with intelligent beings, although he well knew that, according to the laws of gravity, no living being could support its own weight, leaving out of the question other and greater obstacles to their existence.

Undoubtedly among the millions of suns which exist, and which we have every reason to believe have planets revolving about them as our own sun has about him, many are attended by orbs which furnish all the conditions necessary for organic existence. Animal life in thousands of these worlds *may* be in much greater perfection than it is on our own, and beings of such mental capacity and fine physical construction may exist that, unaided by any instruments, they may be able to scan the heavens and read the workings of the universe without the gradual accumulation of facts so necessary to us poor mortals.

These are possibilities among the systems outside our solar system, but they are mere speculations. Within our system we have been gradually forced to conclude that with the possible exception of two (Venus and Mars) our own is the only globe on which animal life can possibly exist; and even these, when compared with the earth, present many unfavorable conditions. We find that only a limited portion of the earth is suitable to the production of man in his greatest perfection. Only a few degrees of heat more or less affect man's mental nature so much that only a few miles breadth of our earth is favorable to his greatest development. How, then, would it be on the planet Venus, which receives four times as much heat from the sun as we do? Being continually surrounded by clouds, she may have the required temperature in some parts, but we must conclude that her climate would be far more suitable to the production of frogs than of men. Besides, if men do exist, they can have no knowledge of the great outside universe from their isolated position. No, we cannot look to Venus for that companionship in space which the human mind so much desires. We are compelled as a last resort to turn our thoughts toward Mars.

Mars travels through space at a distance of about 141 millions of miles from the sun. It receives from that body only about half as much light and heat as we do, and its year is nearly twice as long as our own (687 days). When nearest to the earth it is still 35 million of miles from us, and when viewed through the great Lick telescope would still be about 9,000 miles distant. Its axis is inclined to its orbit 27 degrees, and in consequence a

greater portion of its surface is alternately exposed to and hidden from the sun during the summer and winter seasons than is the case with us. Considering all of these conditions, we should expect that the climate of Mars would be exceedingly rigorous even in the equatorial regions, but observations do not confirm such conclusions.

The ice caps, which can be seen to accumulate at the poles during the winter and disappear during the summer, as the poles are alternately presented to the sun, are not so large in proportion as they are upon the earth. A good telescope gives Mars the appearance of having seas and continents, and during certain portions of the year the continents have been thought to change to a purplish tinge which may be due to the bloom of its vegetation or possibly to the effects of frost on it. Astronomers tell us, too, that they see markings which they can only account for on the hypothesis that they are canals. If they were to tell us that they could see canals on any other heavenly body (even the moon), we should at once say that it was an absurdity, for canals are only made by hands guided by intelligence and engineering ability. But even if we admit that intelligent beings do exist there, it requires a lively stretch of imagination to conceive that they could construct a canal which the unaided eye could perceive at a distance of 10,000 miles or more under unfavorable conditions. We must admit that the canal theory looks extremely doubtful, but not impossible. We want to believe that intelligent beings do exist there, and if we accept the statements of others we have no alternative; although we must believe the inhabitants of Mars capable of making, by some means, a ditch one or two hundred miles wide. Now, let us see what we can find to help us believe all this. The force of gravity there is only one-third as great as here; the specific gravity of the planet is considerably less than that of the Earth. There would be no physical difficulty in a man attaining a height of 30 or 40 feet. With such a laborer, under such conditions, it would not be unreasonable to believe that what would be a ton of earth, or say a cubic yard of Mars, might be moved with each stroke of the shovel.

Again, it is not necessary to believe that these canals were originally made as wide as they are at present. Being made to connect oceans, strong currents may have widened what were originally comparatively narrow channels.

I have been anxious to believe that what is seen are canals, because of my anxiety to believe that the planet is inhabitated, and the anxiety to believe it inhabitated is caused by an unwillingness to have such wonderful astronomical phenomena as those visible only from its surface take place without intelligent beings to witness and appreciate them.

The crowning glory of their heavenly sights would be their moons, which are two in number, and so diminutive that they were unknown to our astronomers twenty years ago (having been discovered by Prof. Hall in 1877). Although they are so extremely small (smaller than any other known heavenly body), they are so near to the planet that the nearest, and largest, appears to the inhabitants about twice the size of our moon, and would give about twice as much light, while the other would only appear to them about one-twelfth as large.

Having diameters of forty and twenty miles respectively, and revolving

about the planet at such racehorse speed, the nearest and largest making a complete revolution in 7 hours and 39 minutes, and the other in 30 hours and 18 minutes, the moons produce before the inhabitants some wonderful and complicated effects. The large moon rises in the west, rushes across the sky and sets in the east within 4 hours and 20 minutes, and in this time passes through all of the phases which our moon does in a fortnight.

The sun sets in the west in an eclipse which is total, and in less than four hours the moon has become first a crescent, then half, then full, with a total eclipse, thus making two total eclipses of the moon and two of the sun, and sometimes three, in a single day.

On account of its nearness to the planet it only passes through an arc of 142 degrees from rising to setting, and if we make no allowance for refraction it appears one-third larger when on the meridian than when on the horizon. Its distance from the planet's surface is only 4,000 miles.

The outer moon (whose distance from the planet is 13,000 miles) rises in the east and continues in sight for 65 hours, during which time it will pass through all of its phases twice, and may have two total eclipses, and eclipse the sun twice before it sets to be hidden from sight for a like number of hours.

Truly "the heavens declare the glory of God and the firmament showeth His handiwork."

Discussion.

Prof. C. S. Howe: More attention has probably been given to the study of Mars within the last 10 to 20 years than before for a great length of time.

Amateur astronomers claim many times to have seen things that have never been seen with the largest telescope known. Every little while we hear of some new discoverer having seen through a six to eight-inch aperture something which had never been seen before and which the largest telescopes have never been able to see since.

A favorable position of Mars for study comes only once in 10 to 15 years. The last favorable position came in 1877 at which time canals were discovered by Schiaparelli. These canals are merely so called. They are streaks of what appear to be water, that separate the surface into small islands.

In the year 1881, at the next opposition, which was not quite so favorable as in 1877, because Mars was not so near the earth, Schiaparelli discovered that the canals were double, with two openings, and the canals were from 100 to 200 miles apart. Mars will not reach the next opposition until in the coming spring, and the next in 1892.

The one way in which we can determine the size of his satellites is by the amount of light they receive. These satellites are the smallest objects known in the heavens.

RECENT DEVELOPMENTS IN IRON AND STEEL MANUFACTURE.

By George Bartol, Member of Civil Engineers' Club of Cleveland.

[Read Nov. 12, 1889.]

The problem in manufacturing iron and steel from pig iron is to get rid of the surplus carbon and silicon and to form the metal into the shapes required.

In case of wrought iron this is done by the puddling process. In the case of steel there are three processes, the crucible, the Bessemer, the open-hearth. In the puddling process the cast iron is put into a re-

reverbatory furnace, the bed of which is lined with refractory material. The iron is melted, and the action of the air, and flame upon it causes oxidation. As soon as the oxidation of the silicon and carbon is complete the iron crystalizes out, it " comes to nature," and is welded together by rolling or hammering.

In the making of steel by the crucible process, a charge of metal with a certain amount of manganese or charcoal, is put into a crucible holding about 80 pounds of metal and subjected to a very high temperature. After a suitable time the metal is put into molds.

In the Bessemer process, the pig iron is melted in a cupola furnace, poured into a vessel called a converter, and air forced through it at high pressure. The silicon is oxidized first—afterward the carbon. Manganese is then added and it is poured into molds.

In the open-hearth process, we make use of what is called a Siemens or regenerative furnace. The hearth is made basin shaped, and is lined with refractory material, as in the case of the Bessemer process. Ordinarily it is lined with silica, which is more refractory and stands more heat than almost any other substance. At each end of the furnace are two chambers of fire-brick, piled up in checker-work. They are so piled as to present the greatest surface, at the same time offering little resistance to gas and air passing through them. In this furnace, gas, which is produced in what are called gas generators or gas producers, comes in through one of these chambers, and air comes in through the other; they combine in flame and go out through the chamber at the other end, the direction being reversed about every 15 minutes. By this means we retain nearly all the heat that is produced by combustion, and at the same time produce a very much higher temperature than if cold gas and air were burned. The cast iron and other materials for the charge are placed on the hearth and melted by the current of gas and air passing over them. There are several ways in which the surplus of carbon and silicon can be reduced. After the process has gone on for quite a time (it usually takes about eight hours for the operation), we have reduced the carbon, the silicon is gone entirely; manganese is added and the steel tapped and poured into molds.

Member: Is manganese added to protect the iron ?

Mr. Bartol: It is supposed that the addition of manganese takes off oxygen and other impurities and makes the steel malleable. For soft steel as much is not used as for hard. In the making of hard steel, like axle steel, about one and one-fourth to one and one-half per cent of manganese is used. So far as I have considered, steel has simply iron and carbon in its composition.

There are several other elements present. Two of them, silicon and manganese, are needed in the process of making steel; and two of them, phosphorus and sulphur, we would be very glad to get rid of, if possible. Phosphorus and sulphur are found in all iron ores, and the whole process of making pig iron tends to concentrate them. Suppose we had iron ore containing sixty per cent. of iron and which has five-hundredths of one per cent. of phosphorus. Passing it through the blast furnace we get pig iron containing ninety-five per cent. of iron and all that phosphorus concentrated in the iron, amounting to eight one-hundredths of one per cent.

of phosphorus. This is again concentrated in the steel. We do not want to have over one-tenth of one per cent. of phosphorus in steel; if there is, it makes it brittle and dangerous to use. The sulphur, on the other hand, makes steel red short, and you cannot hammer or roll it. Thus, iron ores having a small percentage of phosphorus are very much sought after. Almost all iron ores contain a certain per cent. of phosphorus. In some countries there are very few ores suitable for making steel.

In regard to the acid-lined furnace or converter, the silica, at this high temperature, is stronger than phosphoric or sulphuric acid; it goes into the slag and keeps the phosphorus and sulphur in the steel.

A modification of the Bessemer and open-hearth processes, which has only come into use within the last few years, is called the basic process in opposition to the old acid process, and consists in performing its operations on a lining of lime or magnesia instead of silica. This is also called the Thomas process. It was rendered practically possible by Mr. Thomas, and is known by his name in Germany.

Almost all ores in Germany are very high in phosphorus, and it has accordingly been the salvation of the steel manufacture there.

The pig iron, as used in the old acid Bessemer process, contains three per cent. of carbon and two per cent. of silicon. The presence of carbon and silicon are necessary to get the heat required to keep the steel in a liquid state in the converter. In the basic process, phosphorus takes the place of silicon. There are quite a number of furnaces in the city of Pittsburgh using the basic open-hearth process.

Of the steel products from the three different processes, each has its place. The crucible process is gradually being driven out. It is used mostly for the making of the finer grades of tool steel. The Bessemer process is best adapted for the making of rails, tank steel and ship plates, or bridge steel. By it we cannot, with equal certainty, make so fine a grade of steel as by the open hearth; so that the open-hearth process is used for a finer grade of steel than the Bessemer. By the basic open-hearth process we get the very softest metal produced.

Another alloy of iron, of which we have not heard very much of late, is the Hadfield steel. The open-hearth process or the crucible process is used, and about 10 per cent. of manganese is added. This produces a steel which is very hard and has a very high tensile strength, and is very tough, one sample I know of showing about 115,000 pounds to the square inch, with something like 22 per cent. of elongation—all that would come from other steel of 70,000 or 80,000 pounds tensile strength.

As I explained, 80 per cent. ferro-manganese contains perhaps 7 per cent. of carbon, so that it is impossible to make Hadfield steel of low carbon which would be of interest.

Mr. N. B. Wood: Is the Hadfield steel capable of being hardened and tempered?

Mr. Bartol: I do not think it is.

Member: Will it cast freely?

Mr. Bartol: It casts very nicely. That made by Mr. Wellman at the Otis Works is the only instance that I know of, personally.

One of the most important recent developments in steel manufacture is the manufacture of steel castings. A few years ago it was almost im-

possible to make steel castings with any degree of satisfaction, and consequently most castings were of iron. The steel castings made were full of blow holes and they were generally unreliable. This department of steel manufacture has grown up entirely within the past six or eight years. They are now made principally by the open-hearth and Bessemer processes. The metal will run from sixty to eighty thousand pounds tensile strength and possesses a very high degree of ductility and is malleable. If you have a casting which you wish to alter the shape of it can be heated red hot and hammered into the proper shape. If you take the ordinary Bessemer and open hearth steels and pour into a mold you will find that the casting is full of blow holes; these are avoided by the addition of silicon and thorough venting. Steel castings, perfectly solid, have about six or eight times the strength of iron castings.

There have been a great many improvements made in rolling and hammering steel. Rolling mills are now designed with such perfection that it requires few men to operate them, and the output has been increased tenfold within the last fifteen years. Cold rolling has come into use a great deal recently. This has the effect of giving the metal a very true, polished surface.

There are several other processes of manufacturing steel of interest—one, the Mannesmann process of rolling tubes from the solid bar. These tubes can be made of considerable length.

There is another process which promises to be of great importance—the Symonds process of rolling articles of almost any shape, round or cylindrical. You have seen a woman make a cylinder of dough with her hands. This Symonds process is much on the same principle as that.

Laying steel down at too high a temperature crystallizes it. In regard to annealing steel, steel castings should be well annealed. It makes them stronger than before. The question is often asked, Is this steel or iron? Wrought iron, as used, is as nearly pure iron as we can make it. If you find very little manganese you may be pretty sure that it is iron. You cannot always tell crucible steel. If you find it low in manganese you may feel pretty sure that it is crucible steel. The proportion of carbon in steel runs from one-tenth to one and one-half per cent. For very soft plate steel we have one-tenth per cent. of carbon. It runs from that up to two-tenths per cent.

With regard to bridge steel, I think it is perfectly safe that there should be from seventy to eighty thousand pounds tensile strength shown for some parts of a bridge, provided it has the proper degree of ductility.

It is important, in ordering steel, to say for what purpose it is to be used.

Respecting mitis castings, I presume all of you have seen them. They are made from wrought iron with the addition of aluminum. I am not at all familiar with the process, but what I have seen of them were very nice indeed. They are very tough.

DISCUSSION.

Member: What is the best definition of iron and steel?

Mr. Bartol: The definition which I think best for all practical purposes is that steel is malleable and homogeneous. Wrought iron is malleable but

not homogeneous, whereas cast iron is homogeneous, but not malleable. This is as near as you can put it in a few words.

We all know what carbon is in its ultimate form, and we find by testing iron from very high temperature that it contains different carbon from dif. ferent carbon tests. So various other things all show that there is more than one compound in the iron. A very slight difference in the carbon makes a great difference in the characteristics of steel. Carbon is supposed to be present as metal compound, a combination of carbon with the iron. In the case of pig iron we find carbon iron present, but in the ordinary pig iron or cast iron as it is used in the manufacturing of machines, or for any such purpose, a large part of the carbon is free. If you will take a piece of cast iron and break it you can pick out little pieces of carbon with a knife. That might be a thing of interest to dwell upon if we had the time.

As to soft iro , or what is so called soft iron (what we call 1, 2 and 3 iron), a larger part of the carbon is simply mixed with the iron, as in the shape of graphite. Graphite is one of the forms of carbon. If you will break a piece of carbon you can pick it out with a knife.

In regard to the relative merits of open-hearth and Bessemer steel not being worthy to go into bridges, in the open-hearth furnace, where the steel can be retained in the melted condition, you can get steel just as wanted; whereas in the Bessemer furnace it requires experience and care, but if the metal is tested, I do not see why it should not be used just as well as the other.

Mr. Wood: Speaking of the test between the open hearth and Bessemer, it is simply a matter of good manipulation and care. Now you may work iron as much as you want, pull it and roll it over and over again and it is iron still. You may roll out steel, draw it out as many times as you wish and it is still steel. If you will take a piece of good quality of iron, you can bend it backward and forward without breaking it, but take a piece of steel, bend it backward and forward, and it will break.

I think iron is more safe, practically, to use. Steel is dangerous. A piece of steel grate bar that seems to be perfectly tough will stand any amount of doubling one way, but you cannot bend it back. Put it in service a little while and it will crack off. There is no apparent cause for it. I have seen it time after time, sometimes in iron.

Mr. Wellman: It is a common belief that steel is a dangerous material to use, but it is not so in fact. If steel is a dangerous article I would like to know why nine-tenths of the boilers built to-day are of steel. With the steel boilers of to-day there is not one-tenth or one-twentieth of the money spent on repairs that there are on iron boilers, and iron boilers are constantly requiring repairs. They give out in all sorts of ways. Take an iron boiler and put it in use and nine chances to one there is a leak. A man goes into the market for the purchase of a boiler. He buys a steel one because it is the cheapest boiler in the market, and puts it in use, when it very likely cracks on the bottom. He probably bought it at one-half cent per pound cheaper than for an ordinary iron boiler, and then cries, "Steel is dangerous." If steel is well made, it can be used a great deal, but it is impossible to have steel or any other material used by ordinary workmen but what it will be opposed at some time.

Mr. Force: It is generally supposed that steel makes better bridge material than iron. I think recent developments have shown that Bessemer steel is very little better than iron. I can refer to experiments that were illustrated in the American Society's Transactions for a bridge on the Philadelphia branch of the Baltimore & Ohio Railroad. It shows that for long columns in which the length is considerable, steel is very little superior in

strength to iron. I do not think there is much to be gained in using steel for long columns in bridges. It is very seldom used. The best bridges are strictly iron, heavy parts may be of steel, and many of the bars are of steel, but the lighter parts of the structure are of iron.

Mr. Swasey: A few years ago we bought quite a quantity of $1\frac{3}{4}$ iron. It was bought for good refined iron, of an extra quality. A piece of it was cracked and I happened to strike it across an anvil and broke it off. I was surprised and struck it across the anvil again and it broke four or five times in that way. I had considerable fun with it, and went to work breaking iron by hand, and I have never looked upon iron since then as the same kind of material as before.

We can have good iron and poor iron, good steel and bad steel. It makes a difference how many times iron is puddled and rolled. I use steel more and more every day, but do not want to have much to do with iron.

Mr. Wellman: Iron cannot be tested. We have no assurance at all that it is all alike. When it is puddled one piece may be fairly good, while another piece may have a piece of cinder in the centre. One may be full of slag and another may be all right. It is impossible to test it all. With steel a test sample stands for the entire charge.

ASSOCIATION OF ENGINEERING SOCIETIES.

PROCEEDINGS.

BOSTON SOCIETY OF CIVIL ENGINEERS.

NOVEMBER 20, 1889.—A regular meeting was held at the American House Hanover street, Boston, at 19:40 o'clock, President Fitz-Gerald in the chair, 52 members and 17 visitors present.

The record of the last meeting was read and approved.

Mr. Lewis M. Hastings was elected a member of the Society, and on motion of Mr. Manley it was voted to abate $4 from the entrance fee in consideration of the former membership of Mr. Hastings.

The following were proposed for membership: Benjamin W. Guppy, of Boston, recommended by F. B. Rowell and J. P. Snow; and William J. Watkins, of Revere, Mass., recommended by E. S. Shaw and J. R. Worcester.

On motion of Mr. Howe, the Secretary was directed to extend the thanks of the Society to the Massachusetts Dredging Company for courtesies shown on the occasion of the visit to the company's hydraulic dredge on the 30th ult.

On motion of Mr. Whitney, it was voted to refer to the Government the matter of reinvesting the funds of the Society.

On motion of Mr. Hodgden, the sum of $65 was appropriated for library purposes.

On motion of Mr. Hodgden it was voted: That the Government appoint a committee* to consider and report to the Society at the next meeting the advisibility of urging upon the Legislature the necessity of having the sheets of the new State map printed, and placed within reach of the people of the State.

In the absence of the author, Mr. D. E. Moran read a paper by Mr. E. L. Abbott, of the Poetsch-Sooysmith Freezing Company of New York, entitled, "The Freezing Process of Making Excavations in Wet Ground." Mr. Moran supplemented the paper with a very interesting account of the sinking of a shaft through quicksand by this process at Iron Mountain, Mich.

At the conclusion of the reading of the paper, a vote of thanks was passed to Mr. Abbott, Mr. Moran and the Poetsch-Sooysmith Company, for their kindness in furnishing the Society with so instructive and entertaining an account of the freezing process of excavating.

At 21:55 o'clock the Society resolved itself into a Committee of the Whole to take into consideration the new constitution and by-laws.

At 22:45 o'clock the Committee rose and reported back a draft of the new constitution, with the recommendation that it be recommitted to the Committee on Constitution for final revision. The report was accepted and the recommendation adopted.

[*Adjourned*]. S. E. TINKHAM, Secretary.

DECEMBER 18, 1889: A regular meeting was held at the American House, Hanover street, Boston, at 19:50 o'clock, President FitzGerald in the chair. Thirty-nine members and twelve visitors were present.

* The Government has appointed as that Committee L. F. Rice, W. E. McClintock and M. M. Tidd.

The record of the last meeting was read and approved.

Messrs. Benjamin W. Guppy and William J. Watkins were elected Members of the Society.

Prosposals for membership were received from Lewis M. Bancroft, Reading, Mass., recommended by E. H. Gowing and G. H. Barrus, and from George N. Fernald, Portland, Me., recommended by G. L. Vose and W. A. Allen.

On motion of Mr. Howe, the Secretary was directed to convey the thanks of the Society to Commander F. E. Chadwick, of the United States Steamer "Yorktown," and to Mr. Charles Morton, Superintendent of Sewers of Boston, for courtesies shown on the occasion of the visit to the United States Sqadron of Evolution in Boston Harbor on the 4th inst.; also to the Magee Furnace Co., the Low Art Tile Co. and the Lynn and Boston Street Railway Co., for courtesies shown this afternoon.

Mr. Tidd, for the committee, appointed at the last meeting to consider the advisability of urging upon the legislature the necessity of having the new map of the State printed and placed in reach of the people, submitted a report. The report stated: "There seems to be no question as to the desirability of publishing the maps. They embody information of special value to our profession and to members of our society, and not readily obtainable from other sources. The work of collecting this information and of making the maps has been done, but the results are unavailable. These maps are needed *now* in our daily work, but they cannot be put before the country until Congress makes a special appropriation for that purpose. The State of Massachusetts, making application to the proper department, and paying the expense of printing a limited number of copies of the maps, would doubtless be allowed the use of the plates for that purpose, and the maps could be ready for delivery in a few weeks. Your committee can see no valid objection to the action proposed, and therefore reports favorably thereupon."

Prof. Henry L. Whiting, a member of the State Commission on Topographical Survey, spoke of the character of the work which had been done, and of the present condition of the plates. He stated that the Commission would recommend to the Legislature, at its coming session, that an appropriation be made for printing a limited number of the maps. He suggested that any action taken by the Society be in aid of this recommendation.

The report was accepted, and it was resolved, that it was the opinion of the Society that a small edition of the maps should be printed at once. The same committee was authorized to represent the Society in the matter.

Mr. Stearns submitted, in writing, for the Committee on Revision of the Constitution, the new constitution and by-laws which the Society had adopted in Committee of the Whole, with the addition of a by-law in relation to the permanent fund. On motion of Mr. Manley, the constitution and by-laws, as submitted, were adopted, 32 members voting in the affirmative and none in the negative. On motion of Mr. Manley it was voted that the new constitution and by-laws be printed and circulated at once.

Mr. William E. McClintock read a paper entitled "Some Methods of Heating and Ventilating School Houses. The paper was discussed by Messrs. Adams, F. Brooks, Knapp, Manley and S. Smith of the Society, and Prof. S. H. Woodbridge, Mr. Frederic Tudor and Mr. George F. Loring.

Mr. Theodore P. Perkins read a paper describing the system of heating and ventilating introduced in the school buildings of Lynn by Dr. Pinkham, and Prof. S. H. Woodbridge, of the Institute of Technology, gave a very interesting account of a system of heating and ventilating suitable to small school buildings.

[*Adjourned.*] S. E. TINKHAM, Secretary.

ENGINEERS' CLUB OF ST. LOUIS.

DECEMBER 18, 1889:—316th meeting—The club met in the Elks' Club room at 8:20 P. M., President Meier in the chair; 46 members and 4 visitors present. The minutes of the 315th meeting were read and approved. The Executive Committee reported the doings of its 80th meeting, approving the application for membership of B. H. Colby, and announcing the result of the ballot for officers of 1890 as follows: President, F. E. Nipher; Vice-President, George Burnet; Secretary, Wm. H. Bryan; Treasurer, Chas. W. Melcher; directors, E. D. Meier and S. Bent Russell; Librarian and Manager, J. B. Johnson; Manager, J. A. Seddon.

Col. Meier then appointed Past Presidents Moore, McMath and Holman a committee to escort the newly-elected President to the chair. Prof. Nipher on taking his seat thanked the Club for the honor conferred upon him, and expressed his intention of doing the utmost for the benefit of the Club and the advancement of the profession. He then called upon retiring President Meier for an address. Col. Meier responded at some length with a paper treating of the advances made during the year, particularly in the direction of civil, mechanical, mining and electrical engineering. Instances of remarkable work done in these branches were noted. He also considered questions of local interest, the numerous engineering projects on hand in this vicinity, the World's Fair in St. Louis, viewed from an engineering standpoint, the prosperity of the Club and plans for its future, and the desirability of a closer union among engineers of the country. The address was greeted with applause.

The application of B. H. Colby was voted upon, and he was elected to membership.

Professor Johnson announced that he had arranged so that members could secure photographic copies of the Club's picture of the late Professor Smith at $1 each.

Mr. Bryan announced the receipt of several valuable books and views for the Club's room.

The Secretary announced the resignation, in good standing, of Thos. G. Lansden.

The Secretary also read a communication from the chairman of the Executive Committee of the Liederkranz, which body has undertaken the work of erecting a monument to Capt. James B. Eads. The communication suggested the desirability of co-operation between the Liederkranz and the Engineers' Club of St. Louis, in the direction indicated. On motion it was ordered that the Committee on Eads Monument be increased to three, and the communication from the Liederkranz referred to them. Robert Moore was appointed the additional member of the committee.

President Nipher announced the receipt of a telegram from Professor Potter, stating that he had been detained, and expressing regret that it would be impossible for him to present the paper on "Fuel Gas" announced for the evening.

Prof. J. B. Johnson, chairman, presented the following report for the Committee on National Public Works: ordered that the report be accepted and the committee discharged.

ST. LOUIS, MO., Dec. 18, 1889.

REPORT OF COMMITTEE OF THE ST. LOUIS ENGINEERS' CLUB ON THE ORGANIZATION OF A CIVIL BUREAU OF PUBLIC WORKS.

GENTLEMEN: Your committee, appointed in June, 1888, to co-operate with the National Executive Council on the organization of a National Bureau of Public Works, beg leave to report as follows:

The committee considered its first and most important duty to be to bring about a

better understanding of the question, among our own citizens in particular, and in other cities along the Mississippi River. Action had been asked from all these cities, and obtained from some, unfavorable to the passage of the Cullom-Breckenridge bill, and your committee felt it their duty to forestall further action of this kind and to make friends for the bill among those who, under false impressions, were opposing the measure. A 20-page pamphlet was therefore prepared, containing a copy of the proposed bill, and arguments on the same. There were 2,500 copies of this pamphlet printed and over 1,300 sent out by the committee; about 1,000 copies were distributed in other ways, and there are some 200 remaining on hand.

Many indications received by the Committee go to show that the pamphlet has had a considerable influence in making public sentiment in favor of a change in the conduct of our Public Works.

The original bill was favorably reported back to both houses of last Congress, but died a natural death at the end of the second session. The subject will come up before the present Congress, and the prospect for getting favorable action on it is much better than ever before.

If engineers would only unite in asking for fair treatment at the hands of the government, it would probably not be many years before we would have in this country a Civil Bureau of Public Works. If we do not obtain it, it will probably be our own fault. Congress will certainly wait for outside pressure to force them to consider so radical a change, although most Congressmen admit the reasonableness of the proposition.

It is remarkable that the American Society of Civil Engineers would take no action in the premises. The difficulty which has been experienced in obtaining hearty co-operation in this undertaking is a further evidence of the disorganized, unrecognized and uninfluential position of the engineering profession in America.

It is very much to our discredit that we have in this country so inconspicuous a place in the public esteem. It is probably to be explained by the fact that we have all been so busy working at our profession that we have had no time to work for it. American engineers have made for themselves a great name abroad, where engineers have a high professional standing, but we are still ranked along with the artisan class at home.

There are now some indications that engineers are more inclined to co-operate for their mutual benefit. It is hoped that, if opportunity offers, the members of the Engineers' Club of St Louis will do all in their power to have the civil engineering of the country done by the civil engineers. The Civil Works should not be made the means of an experimental education for the United States Military Engineers, in matters entirely foreign to their proper field of military service, for which they have been educated, and to which their services should be exclusively devoted.

STATEMENT OF RECEIPTS AND EXPENDITURES.

Receipts.

Subscriptions from 46 members (mostly in $2 amounts as per appended list)....	$97.00
From an unknown friend in Washington........	1.00
Total........	$98.00

Expenditures.

Printing 2,500 copies pamphlet and electrotyping same........	$84.66
For 1,200 one-cent wrappers........	12.70
Mailing same........	4.00
Expressage (packages to Milwaukee and Denver)........	1.75
Car fare of collector........	2.00
Total expenditures........	$105.11
Indebtedness........	7.11
	$98.00

J. B. JOHNSON,
R. E. MCMATH,
F. E. NIPHER,
E. D. MEIER.
Committee.

Prof. Johnson also announced that the board of managers had, at its recent meeting, decided to change the place of publication of the JOURNAL to Chicago, about April, 1890, and that an address was being prepared on the subject of national organization of engineers.

President Nipher announced that the proposed visit of Prof. T. C. Mendenhall to the city had been deferred until about the middle of January, so that it would be necessary to defer further action about the banquet to be given him.

Mr. Nils Johnson showed the club a pump valve, which had been operated under a pressure of 550 pounds for fifteen minutes with ordinary hydrant water.

[*Adjourned.*] WM. H. BRYAN, Secretary.

CIVIL ENGINEERS' CLUB OF CLEVELAND.

DECEMBER 10, 1889:—The meeting was opened at 8 P. M., Mr. W. R. Warner, President, in the chair. The Secretary then read the minutes of the preceding meeting, which were approved. He also read a communication from the Executive Board, including letters of application from the following persons, for membership in the Club: Sidney Short, President and General Manager of the Short Electric Railway Company of Cleveland, F. E. Bright and L. E. Holden, all of Cleveland.

The following persons were unanimously elected by the Club:

Herman Poole, W. B. Cleveland and Royal Gurley, as active; and Hiram A. Tucker as associate member.

The Committee on Affiliation presented its report and offered resolutions which were adopted by the Club, and Committee continued. A report of the meeting in Chicago of the Board of Managers was given by Mr. Searles with the following remarks:

"The Board met at Mr. Williams' office. Various requests have been made by the different Societies, members of the Association, for action at different times, but as the Board has had no powers outside of the publication of the *Journal*, it has felt some embarrassment about acting.

"Certain amendments were adopted by the Board to be recommended to the different societies for action. They will be forthcoming at the proper time. They provide substantially as follows: On the application of any society, member of the Association, the Board is to recommend that each society appoint a committee, the chairmen of these committees to prepare a joint report giving all the facts set forth and according to the general sense and tenor of the local reports. The Board may recommend to the societies anything pertaining to the mutual interest and policy of the Association in form of resolutions, and the resolutions being adopted by two-thirds of the societies, shall become the law of the Association. The Board would recommend that a member of any society moving to another city and wishing to become a member of a society in that city, may be permitted to transfer his membership upon presenting proper credentials."

Mr. Warner then said: "As the architects have been very busy beautifying the city of late, they have not had the time to put their plans on paper to be presented to-night, but they hope to give the Club something very interesting at some future time, when they will be better prepared. But we have with us here Professor C. F. Mabery, Professor of Chemistry of the Case School of Applied Science, who will give us a lecture to-night on the 'Developments of the Color Industry from Coal Tar Products.'"

Professor Mabery then gave a very interesting lecture which was highly appreciated by all present. It was quite technical; but with his chemicals before him and the blackboard and charts around him, he showed how alizarine, rosanaline, indigo and chinoline dyes are made.

He explained that indigo may be derived directly from coal tar. In the sixteenth or seventeenth centuries it was known as "Devils' Drug," and that, although it was grown and used for coloring purposes by the Egyptians in prehistoric times, it is only within the past 15 years that chemists have been able to make it by the use of ortho-nitro-phenyl-propiolic acid. This acid is produced by the use of ortho-nitro-ditron-cinnamic acid and ortho-nitro-cinnamic acid, a piece of information extremely interesting when it is considered that those formidable substances are produced from the much despised coal tar. He proceeded to make some pure indigo, a better article than that which is grown. He took some ortho-nitro-phenyl-propi-

olic acid and placed it in a test tube along with alkaline glucose, or grape sugar, and some water. Presently the regular indigo color appeared. This alkaline glucose, or grape sugar, is not very sweet. It is an ordinary sugar in one sense, but it is not as sweet as sugar. It is made from corn in the West, and is used largely in making syrups. The sugars are composed of carbon and water; when heated, sugar gives off the water and leaves charcoal. Glucose is perfectly harmless and agreeable to the taste; but, although it can be taken in considerable quantities, it is not wise to take too much of it into the system.

Prof. Mabery also explained how some colors would deposit more readily and are more stable on wool than on cotton, and in the course of his remarks he exhibited to the Club specimens of wool and cotton that had been colored with the different dyes.

He spoke also of rosalic acid, which is a bright color, and which is used largely in making red inks. It deposits very readily on wool, and yet not at all on cotton without a mordant.

The alizarine dyes are particularly stable, while the rosaniline dyes are not. The alizarine and rosaniline colors have been known for 2,000 years, but it is only a short time ago that a German chemist figured out theoretically that he ought to be able to produce them artificially, which was confirmed by experiment, making a use of the waste product of coal tar not thought of before.

A vote of thanks was tendered Prof. Mabery for his valuable and entertaining lecture.

[*Adjourned.*] C. O. PALMER, Secretary.

CIVIL ENGINEERS' SOCIETY OF ST. PAUL.

OCTOBER 1, 1889:—Regular meeting, 13 present. Minutes of last meeting approved. Mr. S. B. Williamson upon vote was elected to membership. Committee, consisting of C. F. Loweth, A. O. Powell and J. D. Estabrook, appointed to report on the proposed union of the local societies with the Am. Soc. C. E. Paper read by Mr. C. J. A. Morris upon the dam for the St. Cloud Water Power Co.

Followed by lunch in Hotel Ryan. GEO. L. WILSON, Secretary.

NOVEMBER 4, 1889:—Regular meeting of the Society. Nine members present.

Report of Committee on Affiliation with American Society of Civil Engineers read and discussed by members present, who agreed with the report of the committee, which was accepted and placed on file; which report in conclusion states in effect that the proposed union is not desirable, as "we believe that the work to be done by the several societies is sufficiently broad and varied to give ample scope to separate organizations; matters of universal or national importance will naturally go to the American Society of Civil Engineers, even if they are originally presented to some local society. The local societies can better attend to matters of local interest and such as pertain to the good fellowship of the profession. To burden the American Society of Civil Engineers with matters of only local interest would be unfortunate, while to deprive local societies of their home influence would be equally unfortunate."

Mr. Powell then read a paper on the United States Laws Relating to the Bridging of Navigable Streams, giving requirements of said laws, references to the same and a variety of information on the subject.

[*Adjourned.*] GEO. L. WILSON, Secretary.

DECEMBER 2, 1889:—Regular meeting of the Society at 8 o'clock P. M.

Thirteen members present. The application of Mr. G. L. Cresson for membership was voted upon and Mr. Cresson was elected.

The paper of the evening was read by Mr. F. Freyhold, upon Methods of taking Topography over Extended Areas.

[*Adjourned.*] A. MUNSTER, Secretary pro tem.

ENGINEERS' CLUB OF KANSAS CITY.

DECEMBER 2, 1899:—A regular meeting was held in the club room, at 8 P. M., Vice-President Filley in the chair, Kenneth Allen, Secretary. There were present nine members and four visitors.

Minutes of the last regular meeting and those of the meeting of the Executive Committee were read and approved.

On canvass of ballots, Thomas Callahan was declared elected Associate.

The subject of Sewer Ventilation was discussed by Messrs. G. W. Pearsons, H. H. Filley, F. E. Sickels and K. Allen.

Mr. F. E. Sickels then read the paper of the evening, on "Snow Plows," illustrated by models from actual practice and drawings. The action of best form of old-fashioned snow plow was to lift snow to sufficient height and then throw to one or both sides of track by mold boards. It consisted of inclined plane with lower edge within two inches of the track, with mold boards or wedges placed upon this, back of its front edge far enough so that action of mold boards would be to throw snow on top of snow at side. If not over nine feet high, it may be placed on four wheels. Axles should be very large, having bearings 4½ inches diameter by eight inches long, in boxes that can slide up and down in pedestal. Then, if plow is heavily loaded (say four tons per wheel), it will do efficient service in ordinary storms. Accidents which have happened to this type of plow have mainly arisen from causes not inherent in the plan, but from the boxes being rigid in the pedestal and front end of plow striking, say, a mass of ice, lifting it up with the wheels, causing plow to leave track.

This has been shown to be very effective in most cases, though the modern rotary plow is more effective in cases where snow and sand have drifted and frozen into a hard, compact mass.

[*Adjourned.*]

DECEMBER 4, 1889:—The annual meeting was held in the club-room at 8 P. M., President O. B. Gunn in the chair, Kenneth Allen, Secretary. There were present eight members.

Minutes of the last regular meeting were read and approved.

The Secretary presented his annual report for the year.

During the year there have been held one annual meeting, nine regular meetings, two adjourned meetings, and 12 executive committee meetings.

ATTENDANCE.

	1889.	1888.
Members—Total	121	169
Members—Average	11	13
Visitors—Total	51	84
Visitors—Average	4.9	6.5

Sixteen papers have been presented during the year, besides the general discussion of sewerage at the November meeting.

The Annual Banquet and a Field Meeting in September were notably pleasant features of the year.

The Committees on Bridge Reform, National Public Works, Transfer of Members and Affiliation of Engineering Societies have done considerable

work, but in each case developments from outside are awaited before further action is taken.

A Committee on Cements and Mortars has been appointed, from which we shall no doubt receive valuable information in the future.

It remains to be settled in what way our Representative on the Board of Managers of the Association of Engineering Societies shall be elected or appointed.

MEMBERSHIP.

	Honorary.	Members.	Associates.	Associate Members.
December 5, 1888	0	62	0	6
Additions	3	17	2	3
	3	79	2	9
Resignations	1			
Deceased	1	10		..
Dropped	7			
Transferred to other class.	1			
December 4, 1889	3	69	2	9
Non-resident Members, December 5, 1888				22
" " " 4, 1889				23

The following candidates for officers for 1890 were nominated:

For President,	W. H. Breithaupt,	H. H. Filley.
1st Vice President,	J. A. L. Waddell,	Henry Goldmark.
2d Vice President,	A. J. Mason,	Thomas Knight.
1st Director,	W. B. Knight,	E. Butts.
2d Director,	W. Kiersted,	O. B. Gunn.
Secretary,	Kenneth Allan,	Henry Goldmark.
Treasurer,	F. W. Tuttle,	A. G. Glasgow.
Librarian,	C. E. Taylor,	F. C. Gunn.

The subject of changing the days of regular meetings was discussed but no action taken.

[*Adjourned.*] KENNETH ALLEN, Secretary.

MONTANA SOCIETY OF CIVIL ENGINEERS.

NOVEMBER 16, 1889.—The regular monthly meeting of the Society was held at the office of Mr. E. H. Beckler. Chief Engineer Montana Central Railway, at 8 P. M., President B. H. Greene in the chair.

There were present Messrs. De Lacy, Helmick, Wheeler, Foss and Haire.

Mr. Geo. O. Foss, of the committee to canvass the letter ballots received since the last meeting, reported that Mr. Charles F. Pearis was unanimously elected a member of the Society.

The Society then adjourned for one week.

NOVEMBER 23, 1889.—The meeting was called to order by Vice-President E. H. Beckler.

Those present were: Messrs. De Lacy, Wade, Danse, Foss, Wheeler and Pearis.

Colonel De Lacy, Chairman of the Committee on Public Land Surveys, submitted a report recommending that the Society address a letter to the Hon. T. H. Carter, calling his attention to the operation and defects of the present system of making such surveys, and requesting him to use his influence at Washington in securing a modification of the present law, and, if possible, a repeal of the contract system of surveys.

It was voted that the report of the committee be accepted and the committee discharged; also, that the letter to Mr. Carter be published in the

JOURNAL OF THE ASSOCIATION OF ENGINEERING SOCIETIES in full, and that the Society procure from the publishers of the JOURNAL 100 copies of the same in pamphlet form for distribution.

On motion of Mr. Wade, the thanks of the Society were extended to Colonel De Lacy and the committee for the able manner in which the subject had been reported upon.

After further discussion the meeting adjourned.

J. S. KEERL, Secretary.

HELENA, Mont., December 2, 1889.

HON. THOMAS H. CARTER, House of Representatives, Washington, D. C.

SIR: The undersigned, at the October meeting of the Civil Engineers of Montana, were appointed a committee to investigate the defects of the present system of surveying the public lands, to endeavor to suggest a better one, and to communicate with you thereon, and ask your co-operation in inducing Congress to adopt it, or something like it, or at least to have the present system amended so that frauds could be measurably prevented, the surveys placed upon a higher plane, and larger and better results obtained for the money expended by the United States.

The present system may be briefly described as follows: At every session of Congress there is a regular appropriation made for the ensuing fiscal year, for the expenses of each surveyor general's office; that is, for the pay of the Surveyor General, his clerks, draftsmen, and other contingent expenses, and each item is specific in its character and can be applied to no other purpose.

There is, however, a lump sum appropriated for surveys for *all* the surveying districts, which varies usually from $50,000 to $300,000. The rates of pay per mile are prescribed in the act making the appropriation. For several years past the rates have been very low, considering that most of the country now remaining to be surveyed is broken and hilly. Some years augmented rates are allowed for ground that is mountainous, heavily timbered or covered with dense undergrowth, and at present there is a very good and tolerably sufficient allowance for land which is entirely covered with timber, with the proviso that it must be agricultural land. Only land settled upon or fit for agriculture can be surveyed. A part of the sum allowed is reserved as a fund for paying for examinations in the field, of all the surveys made during the fiscal year; generally there is reserved about $20,000.

The gross sum appropriated is divided out by the Commissioner of the General Land Office to the several surveying districts, in proportion to the necessities of the service as shown by the estimates made each year by the surveyors general of the different districts. Each one is notified of the sum apportioned to him, of the rates allowed per mile, and of the special regulations which must govern the surveys; and thereupon proceeds to let contracts to surveyors in such parts of his district from which he has applications for surveys from actual settlers. Until the last four years, the surveyor general could place the surveys in any part of his district that he pleased, but at present only those townships can be surveyed which are applied for by the settlers living therein.

The contracts, as drawn up, specify minutely and precisely what lines are to be surveyed; whether base, standard, meridian, exteriors of townships, meanders and subdivisions; the rate per mile for each kind of line is given, and whether augmented rates are allowed. A time is designated within which the surveys are to be executed and the field notes transmitted to the surveyor general's office. There is a bond attached to the contract, and the surveyor and two sureties give security in double the estimated amount of the contract, for the faithful performance of the surveys. One-half of such security must be based on real estate, and it is minutely described in the bond. The surveyor hires and pays his men, and bears all expenses of whatsoever nature. He receives from the surveyor general special instructions as to how, and in what order, he shall make the surveys, and a diagram of them, copies of all of which are sent to the commissioner for his approval. When this is received, the surveys can commence. No substitutions are allowed, and it thus frequently happens, owing to the country where the surveys are placed not being well known, that the surveyor finds on arriving at his ground that the townships which it was supposed would cover the bottom lands and benches of a valley or creek where the settlers are, in reality fall into the hills or bad lands on either side. In such a case he is helpless, and his remedy would be to have his contract annulled and a new one granted which would cover the ground originally intended; all of which takes time and makes expense.

The men who assist the surveyor as chainmen, etc., are sworn, generally by himself, both at the beginning and at the conclusion of the survey, to do their duty correctly, and the surveyor testifies to the correctness of *his* surveys before a notary public, or other civil officer having a seal.

The surveyor himself, according to instructions, should be an experienced, competent and honorable man; the instructions say that none other should be entrusted with the conduct of surveys. He has to have a knowledge of the solar compass, which is a complicated and scientific instrument; he must be able to establish a true meridian by the north star, be able to calculate areas and understand topography and the making of maps. In point of fact, many of them know very little about these things. They have picked up a little knowledge practically; and when anything occurs out of the ordinary course they do not know how to manage it. And this is no wonder, because many of these men have surveyed for years *without* the slightest knowledge of mathematics.

When the contract is completed in the field, the surveyor discharges his hands and returns to his home, where he writes his notes, and sends them to the Surveyor General's office. There they are examined, and if found technically correct, the township and other maps are made, which, with transcripts of the field notes, are sent to the Commissioner of the General Land Office at Washington. Before they are approved by him, an examiner is generally sent out, who goes to each township in each contract, looks over it in parts to see if the corners are properly set, and retraces one or two lines in each one, or at least in several of them. If his report is favorable the surveys are approved, and the surveyor receives his money, and the triplicate plots are forwarded to the local land office, so that the settlers within the townships can enter and obtain title to their land.

I would remark here that for many years there was no examination in the field of the surveys. The surveyor's field notes, as sworn to by him, were conclusive, and, if technically correct, were accepted. His bondsmen were supposed to be liable for any damages occurring in case fraud should be discovered; but in point of fact there is, as far as known, no instance where they have been compelled to pay the forfeit, although there have been thousands of fraudulent surveys.

Such, in a general way, is the system under which the public lands of the United States have been surveyed for the last eighty or ninety years. The rectangular system in itself is an admirable one, easily understood, and simple and easy of application. Up to the time of the discovery of gold in California the surveys were chiefly confined to the older States and to timbered regions. The surveys were also generally in the hands of a class of men who made surveying their profession, who constantly surveyed public lands and who frequently employed the same men every season. Thus all parties were expert in their business; they lived in the country and had reputations to lose. In consequence most of the surveys were measurably well done, and the field notes afforded a great deal more information than they generally do at present. The lines and corners were well marked and could be easily followed through the timber.

With the rush across the plains all this changed. Many of the surveyors, as of all other classes, went to the Pacific coast. There was a vast and untrodden field where new surveys were to be inaugurated, for which large appropriations were made by the government, with large rates per mile. Many of the surveyors who obtained contracts were honest men, who did their duty correctly; but there were many more, not surveyors, who, in collusion with government authorities, obtained large contracts, and speculated in surveys. They would obtain large contracts by "influence," and employ a number of surveyors as compassmen. Time was money literally; only those townships were surveyed which were likely to be soon settled, and while the notes were compiled in the most correct manner, the greater part of subdivisions of townships which they described were never surveyed or marked on the ground, and the topography was entirely false, except, perhaps, on the boundaries. This system finally culminated in the "special deposit" and "Benson" fraudulent surveys, by reason of which the government has paid hundreds of thousands of dollars for surveys which either only exist on paper, or over worthless land. It has extended to all the States and Territories west of the Mississippi River. In Montana there has been very little of this done, for although there has been some indifferent surveying, positive fraud has been very rare.

In all the States and Territories, however, surveyors general and others connected with the public land surveys, complain of bad and fraudulent surveying, and settlers and the government have been put to immense expense and have suffered great losses in consequence. In order to get some idea of the manner in which frauds have been carried on, we would refer you to the reports of the Commissioner of the General Land Office, for the years 1886 7-8; chiefly in the reports of the surveyors general of California, Nevada, New Mexico, Colorado and Arizona, where will be found ample confirmation of what is stated above.

While deprecating these abuses, it is not intended to convey the impression that all or the majority of surveyors do this kind of work. The real surveyor, who depends on his profession for a living, does his work honestly enough. It is the surveying rings which have sprung up as by magic, within the last twenty-five years, which are responsible for the greater part of the frauds.

Within the last five years an effort has been made by the Commissioner of the General Land Office to insure better surveys, and prevent abuses, by a set of stringent rules. Contracts had to be advertised, this being done by posting a diagram of the surveys and proposals for bids in the Surveyor General's and the local land offices for 30 days, the rates not to exceed those specified in the act of appropriation; the contract to be given to the lowest bidder, provided he was a reliable and competent surveyor, with right to reject any or all bids, and an examination of every contract before the account was paid.

These reforms were excellent in their way, and no doubt did much good, or would have done it, other things being equal. It was intended by advertising for bids to have competition, and, consequently, obtain surveys at the lowest price; but the fact was, that while some contracts were let below the regular price, the settlers living in the township had to make up the difference by boarding the surveyor and his men, or furnishing transportation, or acting as assistants, gratis, thus throwing nearly one-half the cost on them. One of the surveyors in this territory, finding that he was unable to make anything, after completing part of his surveys and drawing all his borrowed money from the bank, left the country without sending in his field notes, and the settlers have now been waiting for over three years to have their land surveyed. It is true that another surveyor took the contract, but he has not completed his work, and at least a year more will probably elapse before it is finally complete.

The examination of the work in the field, while it has no doubt had the effect of

preventing "paper' surveys, has been of very little use in determining the accuracy of them. The money allowed for the purpose is insufficient, the examiner is not furnished with an instrument, or chain and pins, and must purchase or borrow them. He can spend but little time on the ground, and frequently can only examine a few corners of a survey, a few lines in each contract, and not enough to show the absolute accuracy of the results reported He is generally an engineer, and not a public land surveyor, and consequently does not know at what point he is most likely to find errors, if any exist

As a consequence of these regulations, the surveying service may be said to have been completely demoralized. In the first place, contracts were taken at very low figures by men who had been assistant engineers on railroads, who were then out of employment, who had never done public land surveying before, and were not acquainted with the ground that they were going to survey, but had an idea that it was easily done. and that they could make money thereby. They soon found their mistake, and that the whole business was literally an up-hill job, and that the only parties liable to make anything out of it were the bankers who lent them money at 12 per cent. per annum to pay their expenses. When their field notes came into the office, they were, almost without exception, incorrectly written, from want of experience, or carelessness, or both, and were returned for correc ion one, two, and even four times.

In addition to this, Congress having made a totally insufficient appropriation for clerk hire in the different offices, the work could not be either examined, or the maps or transcripts made to send to the Commissioner, and the notes had to lie in the Surveyor General's office for several months at a time, until a special appropriation was made for the pay of clerks and draughtsmen.

Under these circumstances, many of the contracts would have lapsed, under the two years' limit, and the money been carried back into the Treasury, had not the Commissioner withdrawn the money therefrom and transferred it to the Surveyor General, as disbursing officer, to pay the contracts when their accounts were approved. Even then, they had to wait until an examiner was sent out from Washington, and his report of examination had returned there and been approved.

In consequence of these and other delays, in several cases more than *two years* elapsed before some of the surveyors were paid, during all which time they had to pay interest on borrowed money. Others were not so fortunate; two of the contracts have recently lapsed, and the unfortunate surveyors cannot get their money until Congress reappropriates it, and legalizes the surveys.

There is another class of persons who all suffer severely from this state of things, and those are the settlers who live on the lands. Many of these have resided on their farms for seven or eight years, sometimes more All of them petitioned for surveys, expecting to have them executed in a short time. Some have had to wait for two or three years before they could enter their lands, and many, even now, after three or four years have elapsed, can get no title. They often write and ask when certain surveys will be approved, so that they will know for certain where their lines will run, so that they can put up their fences and not have to move them afterwards—a great consideration with the ranchmen, and one which they often mention. It is also to be remarked that in case of fraudulent surveys, the settlers are severe sufferers. As they frequently take claims up at the land office, from the township map, the false topography often misleads them, and they find very often that they are not living on the ground which they have entered, and they are for the same reason often engaged in litigation over disputed boundaries.

As to the surveyors, the great majority of them, with the experience which they have had in the last four years, will not take a contract again: certainly not at present prices and with the same delays in getting their money which they have had heretofore.

Although the apportionment for surveys for Montana for this year is $25,000, and there are many petitions for surveys, and that $10,000 of this must be spent on Milk River, where the ground is very favorable, there are few, if any, offers from surveyors. It is more advantageous for them to do any other kind of professional work *where they are sure of getting their pay regularly and at once.*

What has been written above may be summarized as follows:

1st. The system of rectangular surveys, after 100 years' trial, has shown itself to be one of the simplest, most convenient, and most accurate methods of subdividing land ever devised.

2d. The contract system, originally a necessity, and formerly the most prompt as well as cheapest method, has become, in the lapse of time, inefficient, cumbersome, and behind all other modes of surveying in the results which it gives, in addition to which, owing to the frauds practiced, it has in reality, of late years, been very expensive, both to the government and the settlers.

3d. Owing to the nature of the country still remaining to be surveyed, which consists of narrow valleys surrounded by hills or mountains, the small prices allowed, and the delays in payment, it will be almost impossible in a short time to get any one to take contracts, and the system will completely fail, to the great detriment of the government and the settlers.

Many of the surveyors general have advocated a change in the system, but are not all agreed as to what shall take the place of the present system.

The one which it appears to us to be an eminently practicable and practical one, would be as follows:

To do away or abolish the letting of contracts altogether, and have the work done by regularly appointed and qualified surveyors, under the direction of the surveyor general of each district, subject to the following regulations:

1st. When the Surveyor General has received notice of the appointment for his district he should be authorized to employ as many principal surveyors and their

assistants as may be necessary (all to be paid by the government), and the money appropriated will allow, to make such surveys as may be called for by petition of settlers, or may be found necessary by investigation throughout the district. The reason for the last remark is that it is very difficult to get settlers in remote districts to petition; they do not understand it very well, and they think, moreover, that it is of no use. The parties should consist of a surveyor and topographer and the number of chainmen, mound builders, etc., that may be found necessary. Before appointment, the surveyors and topographers should stand an examination from a competent board, of at least three persons, as to their scientific attainments in arithmetic, geometry, trigonometry, plane and spherical surveying, use of tables, calculations of areas, use of and adjustments of the transit, solar and needle compasses, chaining on level and on slopes, making up of field notes and correct descriptions of the ground traversed, with sufficient astronomy to find a true meridian by the sun, the polar and other stars, and sufficient geology and mineralogy to give a fairly accurate description of the different formations which they may encounter in their surveys. To this should be added the use of the aneroid barometer in measuring heights. They should also be tested to see whether they can write field notes according to the Manual of Special Instructions, a matter which comparatively few can do until trained to it. The manual should be entirely re written to accord with the new system.

It might, and probably would be well to cause the chief of each party to give bond for the faithful performance of his duty, with two sureties, who would forfeit a specified sum in case of his making fraudulent surveys. If his work is not found correct at the office, or on examination, he should be obliged to correct it at his own expense, or that of his bondsmen, as should be expressly stipulated, and the bond should hold good for time sufficient for the United States to ascertain whether there has been fraud committed or that the work needed correction.

There would be no difficulty in getting persons who have the requisite qualifications, either from amongst the old class of surveyors, from the railroad service, or from the great number of young men who are yearly trained in our scientific schools. They would receive about the same pay that is given on railroad surveys, and should be continued in service as long as the money lasts and they give satisfaction. We would abolish all oaths, such as the preliminary and final oaths; every practical surveyor knows that these are cobwebs which hold nobody, and do not deter either surveyor or men for a moment, if they intend to do wrong.

The Surveyor General could send out each year one or two such parties, according to the money allowed him, to pursue the surveys at the points where they are most urgently needed, under ample and full instructions from him. Each party could have a district assigned to it, with instructions to start from some point already surveyed; thence run standards and guide meridians which would intersect the country already settled, and that would be found capable of settlement, at favorable points, and from these principal lines execute the exterior and subdivision lines of townships.

Reports and sketches of the work done could be sent constantly by mail to the Surveyor General, who could thus supervise everything and make any changes in his orders which circumstances would render necessary. Field notes and maps could be made by the topographer in the field and forwarded to the office, where they could be at once examined, copied and sent to Washington. In fact, the whole business might be carried on in as correct, practical and economic manner as it would be for a private company or a railroad.

The parties might work all summer, or as far as the funds would allow, and then come to the office and make up their notes and maps, which they are better able to do than any one else, from their knowledge of the ground. They could then be discharged till next year, and the transcripts of the felds and maps could be sent to the Commissioner for examination.

A general field examination of the work done could be made every two or three years by a competent inspector. He could see that in general the corners were properly made, and could take some one or two townships and give them a thorough test with instrument and chain. Any deputy whose work was not up to the standard should not be again employed, and if any fraud should be discovered he and his bondsmen should be prosecuted. In this connection, it is to be remarked right here, that under the present system, the surveyor swears "that if any fraud be discovered in his work he will suffer the penalties of perjury," or words to that effect, and his men also swear to the accuracy of his work; but in case of fraudulent surveys they *do* perjure themselves, and with perfect impunity, as the law, which is stringent enough in its provisions, never seems to be enforced, and it does not seem to be any one's business to enforce it. It is certainly the case, that in former times in this State, at different periods, surveyors have made returns of townships which were in their contracts, but which they had never surveyed, and have received the money therefor; that the facts were discovered in a comparatively short time thereafter, but no effort was made to arrest the surveyors or to make their bondsmen pay the damage accruing to the United States, which in several cases had to pay twice for surveying the same ground. In other States and territories the same has been done, only on a much greater scale. Is it any wonder that these gigantic frauds have been carried on when the perpetrators constantly see with what impunity it can be done?

It is not pretended that under the system outlined above more work would be done, or that it would be less expensive: it would probably be more so. But the work would be much better done, probably more settlers would be accommodated, the surveys and topography would be reliable, a large amount of scientific data would be collected at a small expense, and the description of each township would be in detail and the settlers, other citizens and the government would know something about the country, and the information would be of great value both in a civil and military point of view.

At present the only lines surveyed are the boundaries and section lines of a township; the interior of a section is unsurveyed, and in making up the maps is guessed at. Many of the surveyors have had no training in description of topography and cannot make a map. The details therefore of the section lines are put in by draughtsmen in the office who do not know the country, and the maps therefore consequently are anything but true representations of the ground.

All of the country which it is possible to survey should be surveyed. Where there is agricultural land it should be sectionized; where it is otherwise, the exteriors of townships should be run. High, rugged mountains would, of course, be excluded, unless covered with valuable timber or containing minerals, in which case they should be surveyed.

When it is considered how many millions of dollars have been expended by the government in paying for fraudulent surveys, only partly, or perhaps never, executed, and how many millions have been expended by citizens and corporations in litigation, owing to such fraudulent surveys, it can be readily seen that any system which will prevent these, and give better results besides, will in the end be the more economical of the two. In addition to which, the constant delays which now take place would be eliminated.

Under such a system surveyors would take an interest in their work, and endeavor to give as much information of the country as possible. They would have sufficient time in which to obtain scientific data, and would be able to do all their surveying work properly, instead of hurrying through as they do now in order to save themselves expense. Their records would be of value not only to intending settlers, but to the engineer and other scientists, and the military service. At present no one ever thinks of looking at the field notes of a township for anything except the description of corners and the length of lines.

The Surveyor General and his staff, as at present constituted for the several surveying districts, should be retained. Efforts have been made in the past to concentrate all these offices in a central bureau in Washington; but if this was done it would be a great detriment to the interests of the United States, and of the citizens, particularly in the districts situated in the mining regions.

The Surveyor General of Montana for instance, or any other State in which mining is one of the chief industries, is charged not only with the supervision of agricultural surveys, but also of surveys of lode and placer mineral claims. Where the owner of any lode or placer wishes to have it surveyed for patent he applies to the Surveyor General for an order of survey, and deposits in the United States Treasury a sum varying from \$30 to \$40, to pay for the work done by the office for the claim. We would remark that all the mineral clerks and draughtsmen are paid out of this fund, and not by the United States, and that the Deputy Mineral Surveyors are paid by the claimants and not by the government. Everything being regular, as required by law, an order is given to a Deputy Mineral Surveyor to make the survey. When the map and field notes are returned to the office, they are examined and subjected to every test possible in order to detect any error. Many of these surveys, owing to conflict with other surveyed claims, are very intricate, and their examinations require time and often much research into mineral laws and regulations. If any errors are found they are returned to the surveyor for correction or explanation. If found correct, the requisite maps (from three to four) and transcripts are made; these are sent to the Commissioner, the claimant and the local land office. The claimant or his attorney can then begin his application for patent, and the sixty days' publication required by law, at once, in the local land office, and if there is no adverse claim he can make entry and pay for his lode within three months.

In addition to this, there is a large correspondence to be attended to with claimants, deputy mineral surveyors, and the General Land Office at Washington on mineral matters, and this mineral surveying and business is constantly increasing with the development of the mine.

When a claim is approved by the Surveyor General and sent to Washington, it then takes from *two to three years* to be examined there. Now, if there were no local Surveyor General's office, and the claim had to be sent there first to be examined, was then returned for correction in two years, and then examined in two more, and so on, in what time would the claimant be likely to get his patent? It will be readily seen that the local office of the Surveyor General, with its trained staff of clerks and draughtsmen, is an absolute necessity.

If the contract system should be still adhered to, it might be very much improved in many respects. The rate per mile should be increased; it should not be less than that now allowed for augmented rates; these are, \$13 for standard and meanders, \$11 for township and \$7 for section lines. The rate for section lines should be not less than \$8. The townships generally embraced in a contract at present in this State are not ordinarily contiguous, but often distant from each other, taking time and consequently expense going from one to another, and the agricultural ground is confined to narrow valleys, surrounded by hills or mountains, involving very rough work. In justice to the surveyor, these matters should be taken into consideration in fixing his compensation.

There should be some arrangement made by which the examination of a contract should take place either during the survey, or immediately after it is finished, and it should be more thorough and complete than it is now, and the government should prosecute at once any one found out to have made fraudulent surveys, instead of letting them off, as it has done heretofore.

All of which is respectfully submitted. Your obedient servants,

WALTER W. DE LACY, Chairman,
G. O. FOSS,
CHARLES G. GRIFFITH,
Committee of the M. S. of C. E.

ASSOCIATION OF ENGINEERING SOCIETIES.

ORGANIZED 1881.

Vol. IX. February, 1890. No. 2.

This Association, as a body, is not responsible for the subject matter of any Society, or for statements or opinions of any of its members.

SOME TESTS AND OBSERVATIONS ON BUILDING STONES.

BY J. A. L. WADDELL, MEMBER ENGINEERS' CLUB OF KANSAS CITY.

It is well known to our profession that there is as much to be learned from engineers' failures as there is from their successes; but, unfortunately, we hear very little of the former, for the reason that men are naturally averse to recording their want of success, when it is so easy to avoid exposure by simply keeping silent.

It is probable that the writer is no more anxious than other engineers to score a failure; and, perhaps, were it not the case that the series of tests which forms the basis of this paper proved eventually very satisfactory, it might be that said paper would never have been presented to the profession.

Candidly, it must be acknowledged that some of the tests referred to were unquestionably failures; nevertheless the results of these same tests are truly valuable in that they teach "how not to do it."

Some three months ago the firm of Waddell & Jenkins was consulted by Messrs. Hunt & Harrison of Kansas City, proprietors of the Springfield and Phenix Lime & Stone Co., concerning the value of the product of their quarry at Phenix, Mo., for bridge masonry.

The samples shown to Waddell & Jenkins led them to believe that the stone must be of an unusually fine quality; and upon their ascertaining that the price delivered in Kansas City would be no greater than that usually given for stone of far inferior appearance, it was decided that a thorough test of its qualities should be made; and a contract was entered into to that effect between the two firms just mentioned.

The conveniences for making engineering tests of any kind at Kansas City being almost *nil*, Waddell & Jenkins concluded to go to St. Louis; for Prof. J. B. Johnson of the Washington University had very kindly placed his large testing machine at their disposal.

In order to make the tests of any real value to the proprietors of the quarry and to those who purchase building stone, it appeared necessary to have them to a certain extent competitive, *i. e.*, to pit the Phenix stone

against other stones that are in general use, and of which the good and bad characteristics are pretty generally known.

As the qualities more especially sought were those in reference to suitability for bridge masonry, the stones chosen for competition were the Cottonwood Limestone, which, although by no means altogether satisfactory, has for some time been considered the best available stone for the purpose for this vicinity that can be obtained at a reasonable price, and the Kansas City Limestone, which, although quite often employed for bridge piers, is now known to be essentially and fundamentally bad.

Some thirty or forty cubes of each of the three kinds of stone were prepared, and to these were added half a dozen cubes of Warrensburgh sandstone, as the latter is a building stone that is often used in Kansas City.

Before anything else was done Mr. Jenkins made a trip to the Phenix Quarry, which lies some twenty-five miles to the north of Springfield, Mo., on a branch line of the K. C. F. S. & M. Ry., for the purpose not only of choosing rock for the specimens to be tested, but also to obtain an idea of the extent of the quarry, facilities for working, cost of taking out the stone, cost of dressing, etc. He reported that the supply of stone is unlimited, that the facilities for working the quarry are excellent, that the stone can be split in any desired direction, that blocks of any desired size can be obtained, and that what is technically termed a "crow-foot" runs in places through the rock, which crow-foot in his opinion might or might not be a blemish. This was one of the points to be determined by the tests.

Messrs. Hunt & Harrison have presented to the Engineers' Club of Kansas City the set of specimens from their quarry, which lies on the table before you. These illustrate very clearly the various methods in which the stone can be worked advantageously, and show distinctly the "crow foot" just referred to.

The tests were made in Saint Louis by the writer, assisted by his student, Mr. Taro Tsuji, of Tokyo, Japan. The writer wishes to here acknowledge with many thanks valuable advice and assistance received from Profs. Johnson, Potter and Hambach of the Washington University.

After these few words of preamble, we will now proceed with the report, which reads as follows:

KANSAS CITY, MO., July 26, 1889.

The Springfield & Phenix Lime and Stone Company,

No. 612 Walnut Street, Kansas City, Mo.

GENTLEMEN:—Our final tests on your stone, which were delayed by the breaking down of the testing machine at the Washington University of St. Louis, have just been completed, so we hasten to make you our final report.

In undertaking this series of tests, we did so with the intention of making them comparative, and thus valuable from an engineering point of view. Extremely exact results, such as those made by a chemist in his laboratory, are of little practical use to an engineer, architect or builder when choosing stone for any structure; consequently, we made our tests very severe and of an entirely practical nature. In addition to our usual tests of stone we made several of a peculiar and original character, the results from some of which were quite satisfactory and conclusive, while those from others were not so valuable or distinctive. In all of our tests, however, when any

conclusion could be reached therefrom, the Phenix stone proved either far superior to, or equally as good as any of the other stones tested. The latter included the Cottonwood Top Ledge, Cottonwood Bottom Ledge, Warrensburgh Sand Stone, and Kansas City Limestone.

The latter, although in a number of tests showing high resistance, is so thoroughly unreliable in character that it really ought not to be compared with the more homogeneous stones. For instance, when placed in the testing machine it would show incipient failure and even throw off splinters at a pressure of 1,000 pounds per square inch, and at the same time, when tested rapidly to destruction, would show an ultimate resistance of 8,000 pounds per square inch or more. When left for a few minutes in the testing machine with a pressure of 4,000 pounds per square inch applied, the stone would fail gradually, although the same specimen when tested rapidly to destruction would have developed an ultimate strength twice as great as this. None of the other stones tested showed such abnormal results. Moreover, the actual use of the Kansas City stone in bridges has to our own knowledge proven its unreliability. In cases of selected stone it may stand the action of the weather for from 12 to 20 years, then go to pieces all at once; while in the case of stone taken at random, without careful inspection, it will actually rot or decompose in 2 or 3 years.

The tests to which your stone and the others experimented on were subjected were the following:

First, the soda test, to determine the probable effect of continued freezing and thawing.

Second, actual freezing in a freezing mixture.

Third, absorption of water.

Fourth, the fire test, or heating specimens to red heat, then plunging them into ice water.

Fifth, the abrasion test, made by rotating a number of 3″ cubes of the various stones, together with a number of pieces of scrap iron for an hour and a half in a barrel, then ascertaining with great accuracy the loss of weight of each specimen.

Sixth, the crushing of cubes, both thoroughly dry and partially wet.

Seventh, determination of the specific gravity, or of the weight of a cubic foot.

Eighth, microscopic analysis made by an expert in both lithology and the use of the microscope.

In respect to the first test, two distinct series of tests were made; the first consisted in boiling 3″ cubes of the various stones for half an hour in a saturated solution of sulphate of soda, then suspending these specimens for a week over pans containing the same saturated solution of sulphate of soda, and washing down the specimens three times a day. These specimens were then thoroughly dried and broken, the results being compared with the crushing strength of untreated specimens. This first series of tests with the sulphate of soda was unsatisfactory, for several reasons.

First, the treatment was not severe enough; second, there were not enough specimens to give a proper average, considering that the crushing strength of the stone will often vary without any apparent reason; third, the specimens were broken by another engineer, and his manner of break-

ing may have been somewhat different from ours, especially in regard to the length of time that the specimens were in the testing machine, and fourth, so much time elapsed between drying and breaking of these specimens, that they may have absorbed moisture in varying amounts.

The principal reason for these tests being unsatisfactory is the breaking down of the testing machine.

The effect of this treatment with the sulphate of soda in all cases except that of the Warrensburgh sandstone is to reduce the crushing strength of the cubes.

The second series consisted in boiling in a concentrated solution of sulphate of soda a number of 3″ cubes of each kind of stone for several days an hour or more at a time, several times a day, removing them to let them cool and partially dry, then drying them thoroughly for two days at a temperature about equal to that of boiling water; then crushing them in a testing machine and comparing their strengths with those of thoroughly dried, but untreated specimens. The result of this test can be seen by the following percentages of loss of strength:

Phenix Stone lost	26.3%
Cottonwood Top Ledge stone lost	28.3%
Cottonwood Bottom Ledge stone lost	31.5%

The effect of the soda test on Kansas City stone is apparently less than that under the same treatment upon the more homogeneous stones. For this we can give no reason, unless it be that the great variability of strength which the Kansas City stone showed in the testing machine renders it impracticable for us to draw conclusions of any value from the small number of tests on that stone, both treated and untreated.

The second test, viz.: actual freezing was a partial failure on account of the impracticability of obtaining a very low long-continued temperature. Comparative results could only be obtained by heating frozen specimens upon an iron plate covered with a closed iron cylinder by means of a Bunsen burner. The results, although unsatisfactory, showed the decided inferiority of the Kansas City stone and a slight superiority of Phenix stone over the Cottonwood. A few of the frozen cubes were afterwards broken in the testing machine, and showed that the effect of the treatment was a considerable loss of strength, but the number of specimens so treated and crushed is too small to permit of our making any deductions therefrom, either quantitative or comparative.

The result of the third, or absorption test, was as follows, all the specimens being approximately 3″ cubes:

Phenix stone absorbed	5	grammes, or	0.42%	of its	weight.
Kansas City stone absorbed	18	" "	1.6 %	"	"
Cottonwood Top Ledge absorbed	47½	" "	4.7 %	"	"
" Btm. " "	46	" "	4.6 %	"	"

The surprisingly small amount of water absorbed by the Phenix stone proves conclusively how close grained it is. This could have been to a certain extent surmised by inspection of the fractured stone, and has since been confirmed by the microscopic analysis.

The fourth or fire test was so severe as to break up all of the specimens subjected to it, consequently, no comparative results were obtained. In any

case, only negative results could have been had, because if any stone stand such a test, it is very good evidence of its superiority, while failure to stand it is no evidence of its inferiority. Such a severe test could never occur, even in a burning building. It might be that a more moderate heating would give comparative results of some value, but all limestones will succumb to excessive heat.

The result of the fifth or abrasion test is as follows:

Kansas City stone lost	6.7%	of its	weight.
Phenix stone lost	7.2 "	"	"
Cottonwood Top Ledge stone lost	23.6 "	"	"
" Bottom Ledge stone lost.........	17.8 "	"	"
Warrensburgh sandstone lost	61.0 "	"	"

This test shows conclusively the great superiority of both the Phenix and the Kansas City stone over the Cottonwood limestone and the Warrensburgh sandstone to resist abrasion by ice, when used for bridge piers, but would cut no great figure in respect to the value of stone for building purposes.

The result of the sixth or crushing test is as follows, the figures giving the ultimate resistance per square inch to crushing:

	SLIGHTLY DAMP.	DRY.
Phenix stone	8,150 lbs.	10,000 lbs.
Kansas City stone	6,800 "	9,000 "
Cottonwood Top Ledge	4,630 "	5,400 "
" Bottom Ledge		8,140 "
Warrensburgh	2,900 lbs.	3,050 "

It seems hardly fair to compare these ultimate crushing strengths because of the widely varying characteristics of the different kinds of stone, but considerable valuable information was obtained by closely watching the manner in which the different specimens failed.

The Phenix and Cottonwood specimens almost invariably collapsed all at once, showing that they can be relied upon to resist high pressures. The Warrensburgh stone broke in the same manner. Specimens of this stone were scarce, so it was necessary to use as a dry specimen one that had previously been frozen, and which must have absorbed a portion of the freezing mixture, thus, perhaps, slightly decreasing its ultimate resistance. Then, again, on account of the high absorptive power of the Warrensburgh stone, the specimen when placed in the testing machine probably absorbed from the damp plaster of Paris, which was used for procuring an even bearing, more moisture than did the limestone specimens. However, a crushing strength of 3,000 pounds per square inch is not very bad for sandstone.

It is not to be expected that a dolomitic limestone, like the Cottonwood stone, containing, as it does, a large percentage of magnesia, should have as high a resistance to crushing as the purer limestones, like the Phenix.

The Kansas City stone selected for testing was probably as good a specimen as could be found in this neighborhood, while the specimens of the Phenix stone were taken from various parts of the quarry, some even from the exterior portion of the top ledge, which, as a rule, in most quarries is cast aside or used only for ballast.

A special crushing test was made to determine the effect of the "crow-

foot" upon the stone, and, strange to say, the specimens containing the "crow foot" gave a higher resistance to crushing than did the other specimens.

The result of the seventh test is that the Phenix stone weighs 164 pounds per cubic foot, on an average, and that it will not vary more than two pounds either way from this amount.

The eighth or microscopic test was made by Professor G. Hambach, of the Washington University, St. Louis, who is acknowledged to be an expert upon matters pertaining to lithology and microscopic analysis. He reports that both the top and bottom ledges of the Cottonwood stone are decidedly inferior to the Phenix stone. In reference to the latter he says: "I think it would stand the weather as well as any other limestone. Even the seams ('crow-foot') do not cut any figure, in my opinion, that is, if they are like those in the specimens examined."

Professor Potter, who occupies the chair of geology and mineralogy in the Washington University, and who is manager of the St. Louis Sampling and Testing Laboratory, expressed the same opinion concerning this "crow-foot," and said that he did not consider it to be a blemish or cause for loss of strength or durability. He and Professor Hambach unite in the opinion that the Phenix stone is the Burlington or Encrinital limestone—the lower member of the sub-carboniferous, the supply of which is unlimited. The Cottonwood stone and the Kansas City limestone belong to the coal measures.

In conclusion, we will express, according to your request, our opinion concerning the value of the Phenix stone for bridges and buildings.

We consider that there is, in this district, no stone that we know of, excepting granite, that will at all compare with it in value for such purposes; and the use of granite, on account of its great cost, is generally out of the question. Compared with the local limestone, nothing further need be said, for we do not consider this at all suitable for use, except, perhaps, for the foundations of light and unimportant buildings. Compared with the Cottonwood stone, it is in every way superior, and has one great advantage not hitherto mentioned, viz.: that it is susceptible of receiving a high degree of polish, being comparable in this respect with marble. On account of its low absorptive power, the Phenix stone is very suitable for damp foundations, and on account of its high ultimate resistance to crushing, it is eminently adaptable for foundations of large and heavy buildings where the pressure per square foot runs high, as is sometimes unavoidably the case.

Trusting that this report will meet with your approval, we remain, gentlemen,

Very respectfully yours,
(Signed), WADDELL & JENKINS,
Consulting Bridge Engineers.

We will now proceed to discuss, in their proper order, the various tests made, and to note what changes in methods would be advisable, if another similar series of tests were contemplated.

First. The Soda Test. In order to obtain satisfactory results from this test, at least eighteen cubes of each kind of stone to be tested would be

required. They should be either 2″ or 2½″ cubes—probably the former would be better—as the 3″ cubes are rather bulky. Six cubes should be thoroughly dried, then broken in a testing machine so as to obtain an average resistance to crushing. If the stone be of uniform quality, these six specimens would give a fair average, provided that the manner of manipulation in the machine were uniform, as it should invariably be; but if the quality vary decidedly in the different specimens, the number of the latter, both treated and untreated, should be increased.

The remaining twelve or more specimens of each kind of stone, after being distinctly marked, should be boiled twice a day for an hour at a time in a concentrated solution of sulphate of soda (as described in the report) for fifteen days, at the end of which time, one-half of the specimens should be tested, the boiling and drying process being continued on the remaining specimens fifteen days longer. Before crushing, each treated specimen should be thoroughly dried.

To dry the stones, first keep them in a warm place for two days, then just before testing place them in an air bath for two hours, so as to drive off any moisture that may have been absorbed. Of course, if the specimens can be kept in a warm place until they are put in a testing machine, the use of the air bath can be dispensed with. The main object should be to have all the specimens tested exactly alike.

There should be not less than three different kinds of stone represented in this test, in order to obtain comparative results; and the more that is known concerning the qualities of the reference stones, in respect to their action when in actual use, the better.

The soda test, in which the specimens after half an hour's boiling, are suspended over the solution, then washed occasionally, so as to determine the amount of stone that falls, is, in the writer's opinion, of no account whatsoever, as the amounts thus measured are almost infinitesimal. An engineer requires more tangible and distinctive evidence than this test can afford; moreover, the slightest accident in manipulation might jar off a piece of stone that would weigh much more than that which could be worked off by the solution.

The action of the latter is due to the crystallization of the sulphate of soda and its consequent expansion in the pores of the stone, resembling in effect the action of frost on water that has been absorbed.

One might suppose at first thought that the greater the porosity of the stone, the greater the effect of the crystallization; but such is not necessarily the case; for if the pores were large and constituted a large portion of the mass, there might be room *for* the crystals to form without displacing any particles of the stone. The writer is led to conclude that such may be the case by the fact that the sulphate of soda manipulation appeared to have no deteriorating effect on Warrensburgh sandstone, which is very porous, in comparison with limestones.

Second. The Freezing Test. Judging by the experience obtained in making this series of tests, the conclusion has been reached that the employment of a freezing mixture is practically useless, for various reasons. First, if special arrangements be not made to prevent radiation, it will be found impracticable to obtain the lowest possible temperature than can be

produced from the mixture, and, even if it could be reached, it could not be retained for more than a few minutes at a time. Again, a long continued alternation of freezing and thawing is necessary to produce any appreciable effect; and as the process is both tedious and expensive, it would be better to employ a simpler and more effective one.

Such a process, time permitting, is attainable; and, if a number of the proprietors of first class stone quarries in this vicinity can be induced to join in the test, the writer purposes undertaking it. A test by actual freezing is one of the best and most satisfactory that can be made, appealing as it does to the common sense of everyone interested. Frost is one of the greatest enemies that masonry has to contend against; hence if a certain stone show by actual, long-continued freezing, tests that it can resist the action of frost better than can certain other stones, that stone will be preferred when sold in competition with the others.

The method of conducting the test referred to would be as follows:

At least eighteen 2 in. or $2\frac{1}{2}$ in. cubes of each kind of stone to be tested would be prepared, one third of the number being broken after a thorough drying in order to determine the crushing resistance of the untreated stones. Two or more flat wooden boxes with covers, divided nto cubic compartments to contain the specimens would be prepared, provision being made to draw off all water that might otherwise collect in the boxes.

Each specimen before being placed in its compartment, would be accurately measured and weighed after being thoroughly dried.

The boxes, when filled, would be covered and locked; then about the beginning of cold weather would be sent to a reliable party in Canada for manipulation.

This would consist in first soaking the stones in water, then alternately freezing and thawing them daily throughout the entire winter, one box being drained before freezing, and the other being frozen in a pan of water. At the end of the winter the boxes of specimens would be returned, then each stone after thorough drying would be weighed and crushed, thus determining the loss of both weight and strength due to the treatment.

It is more than probable that porous sandstone would suffer severely by this test, even if unaffected by the treatment with sulphate of soda.

Third. Absorption Test. This, although a very useful and satisfactory test, should not be considered a conclusive one in respect to the suitability of a stone for building purposes; for it is possible that a stone which absorbs but little water may deteriorate in use much more quickly than another stone that absorbs considerably more water.

Fourth. Fire Test. This is a good test, but as in the last case is not conclusive; for a stone that will stand it is very probably good for building purposes; while one that fails under it may or may not be unfit for same. It is possible that if a more moderate heat were to be employed than that used in making the tests just described, the results would be more distinctive and satisfactory. It would be well to try the effect of repeated heating and sudden coolings, the temperatures employed being constant, con-

tinuing the test until all the specimens be rendered worthless, and noting how each specimen bears the treatment.

Fifth. Abrasion Test. No more impartial or convincing test than this could be devised, for the specimens of the various kinds of stone are all treated at the same time and are subjected to exactly the same conditions. The results show indubitably the order in which the various stones resist abrasion combined with impact, such as that to which bridge piers are subjected by floating ice and trees. It is barely possible, though, that after a number of years in actual use in bridge piers the stones when subjected to this test would indicate a different order of resistance.

For abrasion pure and simple without impact, a grindstone test would be conclusive. In this each specimen should be held by a constant pressure for a certain time against a grindstone run at a uniform velocity by machinery. Then, if the specimens be of exactly the same dimensions, the percentages of weight lost by the grinding will indicate the order of resistance. As this test is not of as practical a character as the abrasion test previously described, it was not made when experimenting upon the Phenix and other stones.

Sixth. Crushing Test. This, the most common of all tests for stone, cannot always be relied upon to give even comparative results, unless all the tests considered were made by the same person and in precisely the same manner. The time element is a most important factor; because a specimen when tested rapidly may indicate a greater strength than it would if tested slowly. Then again, it is a matter of judgement as to the exact period of the test when a specimen may be said to fail. The kind of cushion employed (or substance interposed between the specimen and the machine) will materially affect the result. Lead, which was commonly employed a short time ago, has fallen into disuse. Its effect appears to be a splitting of the stone caused by a flowing of the metal into the irregularities of the compressed surfaces, thus indicating a lower resistance than could otherwise be developed. A thin layer of plaster of Paris gives the best and most uniform results; nevertheless, the water used in mixing it acts as a disturbing element by soaking into the stone when squeezed out of the plaster by the pressure. Pieces of blotting paper placed between the stone and the plaster of Paris reduce the effect of this disturbing element.

As a rule it requires more tests than are ordinarily made upon any one kind of stone to determine its average resistance to crushing, as even the most homogeneous-appearing stones vary materially in strength when subjected to this test.

Again, the dryness of a specimen will affect its crushing strength. Each kind of stone should be tested both when thoroughly dry and when saturated, and enough specimens should be broken in each case to determine a reliable average.

A knowledge of what pressure a stone will bear when thoroughly soaked in water is very desirable for an engineer when dealing with masonry below water line.

The size of the cubes tested will affect the value of the resistance per square inch to crushing, as is shown by the late General Quincy A. Gill-

more in his treatise on "The Compressive Resistance of Freestone, Brick Piers, etc."

Seventh. Specific Gravity Test. The making of this test is a comparatively simple matter, especially as no extreme accuracy is required. It will suffice to measure carefully all the dimensions of a number of cubes, and to weigh the latter without drying them. The weight per cubic foot will be found to vary from one to three pounds on each side of the average, the amount of variation depending upon the homogeneity of the stone, a small variation being a good characteristic, in that it indicates uniformity of composition.

Eighth. Microscopic Test. This test, which as applied to building stone is quite new, is said by good authority to be the best of all tests for stone. It requires to be made by one who is a specialist in both lithology and microscopy.

These eight tests are the only valuable ones that the writer knows of: should any others be brought to his notice by discussion on this paper, he would be greatly pleased.

As building stone is liable to failure and decay from a number of causes, in testing any stone for its suitability for building purposes, every test known to give any good indication whatsoever as to practical characteristics should invariably be made. Any one of the tests might prove its unfitness, even if the results of all the other tests were specially favorable.

Judging by what the writer has seen when inspecting bridges in Kansas City and vicinity, he has been led to the conclusion that many of those who are responsible for the masonry piers and abutments did not pay sufficient attention to the quality of the stone employed therein. In a number of cases it is cracking up into small cubes, while in others it is actually decomposing or turning into clay, and can be cut out of the wall in large slabs with a pen-knife. Probably the latter effect is due to careless inspection; for in one case that came to the writer's notice there were only three or four inches of depth in each layer that were decomposing. This could probably have been foreseen, and the perishable part might have been removed, leaving the remainder in much better shape as regards durability; but even then the piers should not have been built of such stone.

The truth of the matter is that the stone quarried in the immediate vicinity of Kansas City is entirely unfit for use in bridges and buildings. Its cheapness is its only advantage. The best of it when in use may act satisfactorily from twelve to twenty years, then begin to disintegrate rapidly.

Of course, it is possible to repair such work with beton, and thus check the disintegration; but such repairs are expensive, and should be avoided by using a better quality of stone. In short, the employment of an inferior quality of stone in masonry for bridges or buildings, merely because it is a trifle less expensive as to first cost, is a false economy for which there can be no excuse.

ADDRESS ON RETIRING FROM THE PRESIDENCY OF THE ST. LOUIS ENGINEERS' CLUB.

BY COL. E. D. MEIER, MEMBER ENGINEERS' CLUB OF ST. LOUIS.

[Read December 18, 1889.]

A time honored custom requires of your president, on transferring to the hands of his chosen successor the powers and honors you had conferred upon him for his year of service, that he give a brief review of the progress in engineering during the year, with special reference to such work as fell to the lot of our club to perform. So liberal is the construction of this duty that individual fancy or bias may meander at will in this broad domain, giving haply a rough general sketch of the topography of the newly discovered country, without anxiously weighing or determining relative heights and distances; dwelling, perhaps, lovingly on some favored spots and ignoring others or passing them by with a careless dash of the pen; and again measuring a recent discovery by reference to a tide-mark reached ages ago, or venturing boldly on prophecies of what the next decade or even century may bring. You have established for yourselves so high a reputation for patience and complacency that each new lecturer feels safe in choosing his own subjects, his own methods and his own limits.

These fortunate circumstances alone make my venture possible, for how can more than a brief and rapid birds-eye view of the year be given in the limits of a paper which may claim but a small portion of the evening.

The year just closing has landmarks of its own in most departments of engineering.

The bridge over the Firth of Forth, just completed, has in its two cantilever spans of 1,720 feet each, reached the greatest limit of free span yet attempted in a railway bridge. Our own bridge may be credited with the honor of giving impetus in the direction of long spans, and I may note here a coincidence which seems almost an unconscious prophecy. Its three spans aggregate about the clear opening of one of those of the Firth of Forth. Upon its completion one of the master minds engaged in its design and construction (the first president of this club) said: "Had we known when we began what we have learnt during construction we should have built our bridge in a single span of 1,600 feet."

And yet, but a few years before, at a meeting of the most prominent bridge and railway engineers of the time, a resolution condemning the 500 feet spans of our St. Louis bridge as "a design of criminal impertinence" came within a few votes of passing as the deliberate opinion of the body. In our own country we find the magnificent cantilever bridge over the Hudson at Poughkeepsie opened for traffic during the past year, a fine bridge with 551 feet cantilever spans thrown across

the Kentucky river at Tyrone, the first two piers placed for the Mississippi bridge at Memphis, a bridge of a half mile in length with 428 feet spans, begun across the Missouri river at Kansas City, and the Ohio bridge at Cairo completed. On the latter the remarkable feat of erecting a 518½ feet span in less than forty-eight working hours was accomplished, showing an executive ability, and an accuracy of detail truly marvelous, and practically illustrating Emerson's definition of genius as the "capacity to take infinite pains" so comforting to every plodding engineer. The same bridge builders made an equally good record on the third span of the Merchants' bridge at St. Louis, which being for double track, weighs 50 to 60 per cent. more, and which was fully erected in sixty-one working hours.

In the modern Babylon, no doubt fully the peer of its ancient prototype in art, in magnificence, in vast wealth and sordid poverty, in beneficent public charities, in hidden crime and flaunting wickedness, the great tower has been successfully completed within this single year, amid a much greater confusion of tongues than that which baffled the ancient architects, Gallic suavity thus proving superior to the proverbial stubbornness of the Mede and Persian. This tower of steel, 1,000 feet high, may serve us as a comparative measure of progress on such structural work, when we place beside it the Latting observatory, an unsightly octagonal tower of timber, 350 feet high, built in New York, at the World's Fair of 1853, without elevators, but containing a circular staircase which was temptation enough to induce 2,000 hardy visitors to mount wearily to the top.

While the new Croton aqueduct has steadily progressed through miles of tunneled rock, the railway tunnel under the Hudson has during the year been recommenced after a long halt in the work.

Even Mexico comes to the front with a drainage tunnel to be driven through practically thirty miles of rock, and intended to control the periodic inundations from the six large lakes which surround the capital, in a valley with no natural outlet; on this project work has been begun and very fair progress made.

The Panama canal has been abandoned after the expenditure of $300,000,000. Our regrets at this untimely end of one of the greatest projects of modern times, is tempered by the knowledge, now gradually becoming public property, that *no* thorough survey or professional discussion preceded the actual commencement of the work, and that, therefore, this failure must be debited to modern scheming and speculation and not to modern engineering.

All indications regarding the Nicaragua canal, on which work has been begun during the year, lead to the belief that the magnitude and character of the difficulties in its way have been studied with cool American forethought, with the fires of enthusiasm well banked for its completion, which is promised for 1894.

The vast calamity following the bursting of the South Fork dam has now been investigated in all its bearings, with the satisfactory result that the engineers who built and maintained the dam are in no wise responsible for the loss of some 4,000 lives and $9,000,000 of property. The actual cause of the fearful wreck was a waterspout or cloudburst of vast dimensions, against whose titanic force human ingenuity and forethought were

vain. Evidence enough of this truth was found, for months afterwards, in the flood marks of the canons on the eastern slope of the divide, where no fishing pond or broken dyke measured the deluge which swept forest, village, track and trains as conglomerate debris into the fertile valleys below. From personal observation, a year before, of the destructive effect of a rainstorm of no extraordinary magnitude, in the gorges of the Conemaugh and the Kiskeminitis, I can acquiesce in the verdict.

The marvelous rapidity with which the Pennsylvania railway company replaced the obliterated track and bridges establishes another record in railway engineering and organization. An army of 7,000 skilled graders, rockcutters, track layers and bridge carpenters made a new road in twelve days, although miles of road-bed had to be built anew, and over 2,600 feet of bridges constructed. In one instance a bridge 258 feet long and weigh-250 tons was moved forty-five feet in twelve hours.

It is gratifying to turn from this to another perennial flood controlled by the genius and persistent energy of our late lamented Eads, whose jetties have during the year successfully passed their ten year test, and thus make deep water connection from river to gulf an assured commercial success.

Among the many interesting schemes proposed during the year, and for which preliminary surveys have been made, is the resurrection of the supposed Lake Moeris of the Pharaohs, at the instance of an American traveller and prospector. The productiveness of modern Egypt is to be doubled by the daily delivery from this lake of 12,000,000,000 gallons of water for irrigation during the periods of low Nile. The Yankee, of course, proposes to restore and use the entire system of canals built by the celebrated Hebrew hydraulic engineer, Joseph, whom neither perversely partial paternal training nor innate race tendencies toward gorgeous raiment could turn from his self-imposed severe professional work to the ornamental ease of the scented Egyptian dude.

Turning from civil to mechanical engineering, the most striking advance is found in the means of transportation of persons and property. The "Ocean Greyhounds" have chased each other westward and eastward until the latest "record smasher" has brought her hundreds of passengers and cargo of freight across the Atlantic in the short space of five days nineteen hours and eighteen minutes, making an average speed of somewhat over twenty-three statute miles per hour. The enormous power necessary to accomplish such results could not be carried and maintained for this length of time but for the modern triple expansion engine which has reduced the coal expenditure, and hence the necessary dead load of fuel, to about one-half of that necessary fifteen years ago.

That all these magnificent racing palaces come into our ports under foreign flags is due to that fallacious policy of protection which ignores the fact, that all human progress has been made *because* of the obstacles intervening between desire and enjoyment.

Forced from the high seas by pauperizing legislation, our marine engineers must find their field on the great lakes and sounds of our coast. Triple expansion engines have been largely introduced on the lakes, and

an exceedingly swift Sandy Hook steamer, the Monmouth, is equipped with them.

As types of construction essentially American the Sound steamers Puritan and Connecticut must be mentioned. The former is pre-eminent as much as a first and successful experiment in chaste artistic decoration of a steamboat, as for her immense size and great speed. Her engine is of the well-known type, but the working-beam is entirely encased in what we in the West would call the Texas. The Connecticut presents a bold departure from accepted canons. She has a compound oscillating engine with cylinders $56\frac{1}{2}''$ and $104'' \times 11'$ stroke. The balance of these immense masses of machinery is perfect, and only a slight heating in one of the glands—to be corrected this winter—has prevented her from being run at full speed. But, thus curtailed, she always made her trip inside of time limits, while the position of all the heavy machinery low down made her a very steady sea-boat.

Our new navy is progressing at as rapid a rate as so peaceful a nation could wish. Four new cruisers and a dispatch boat are in service, and four more have run successful acceptance tests. One of the latter is reputed to be the fastest armoured cruiser afloat. The success of American shipyards in this work again suggests that Americans would no doubt soon learn to swim could once the maternal congressional prejudice against water be overcome.

On shore we may chronicle the general introduction of vestibuled trains during the year as a sharp advance in the comfort, speed and safety of inland transportation. An unintentional experiment by the "Congressional Limited" on the P. R. R. at Trenton was a successful demonstration of the safety of this new device. Running from the track at the full 60 mile speed, the train held together intact and came to a halt, as a unit, after about 200 yards of rough riding over ties and ballast, without serious injury to a single passenger or employee, but with such total destruction of the track that traffic was delayed for fully 12 hours.

Compound locomotive engines have been introduced during the year, one by the P. R. R. imported with runner and machinist from England, the other built for the B. & O. Ry. by the Baldwin Locomotive Works. This latter has four cylinders, two to a side, respectively 12″ and 20″ by 24″ stroke. During the year these works turned out their ten thousandth locomotive.

A remarkable feat in erecting was accomplished a few months ago at the Penna. R. R. shops at Altoona. A complete new locomotive was assembled by two gangs of erectors, in just 16 hours from the time the boiler was placed on blocking over the shop track to the moment the engine steamed out into the yard.

Two Western corporations have been conspicuous in the development of the triple expansion engine for stationary power, and have made guarantees of furnishing a horse power on less than 13 lbs. of steam per hour, which is equivalent to 150 million foot pounds duty on the basis in vogue for pumping engines. Such engines naturally find their way into the large electric light and power plants now being installed in our cities. This is a long jump forward from the 30 lbs. of Centennial rating, and the 25 lbs. or

at best 23 lbs. Corliss guarantees, but seems like almost barbarian wastefulness when compared to the 90 per cent. efficiency of the modern dynamos.

The electrical engineer finds before him a field broad enough for the highest ambition, deep enough for the most insatiate scientific analysis, and bright with promises of power over the elementary forces compared with which the prodigious accomplishments of steam engineering are but as the rush light of the past to the electric torch of the statue of Liberty.

Even now in the infancy of the new art it is impossible to enumerate the manifold uses to which the subtle current has been compelled to lend its power. Bound in the simple harness of the motor it drives elevators, printing presses, sewing machines, looms and roller mills; shifts heavy consolidation locomotives on the transfer tables of repair shops; lifts and carries massive machinery from lathe to planer, from drill press to erecting shop, throws the drawbridges of railways over navigable streams; lights the wrecking train on its nightly works of salvage, or hoists heavy shells from the magazine to the monster gun of the modern ironclad; thwarts the night attack of the torpedo boat by the revelations of the flash light; increases the traction of the heavy freight engine in flitting from tire to rail; guides the surgeon's lancet on its mission of relief or inflicts the extreme penalty of the law at the touch of a button; carries millions of passengers over our streets with a speed and safety impossible to cruder forms of power or stops heavy machinery at the break of a mere gossamer thread; fuses dissimilar metals together, or warms cosy parlors with the transmuted energy of the distant wintry cataract. It is in short the ideal power of the future, capable of infinite development as we learn to control and guide it.

If a Russian kindled the first arc light, if English thought glowed in the first incandescent filament, if an Italian wound the first practical armature, and a German first harnessed the current to his car, the great development of electricity in the service of man is due to American enterprise, pluck and perseverance. American electrical engineers now light the streets of London and Berlin, a Western Aladdin illumined the splendors of the Paris Exposition; a Yankee inventor welds the silver threads of the jeweler or the stout cable chains of the ironclad, and in our country alone has electrical traction reached commercial proportions and success. While in 1885 we had three electrical railways with 7½ miles of track and 13 motor cars, we have now in actual operation 109 roads, running 936 motor cars on 575 miles of track, with several thousand more in process of construction. In the safety due to perfection of control; in speed which may be varied from that of a slow walk to quicker time than is possible to elevated steam roads; in equal adaptability to suburban or metropolitan conditions; in capacity for indefinite enlargement of existing plants, and in the practicability of locating the power house wherever fuel and water for condensation are most available, the electric railway is pre-eminent. Electrical telpherage has received a new impetus by the construction of the Weems elevated road at Baltimore, for express and mail carriage, which has experimentally attained a speed of 120 to 180 miles per hour.

In the metallurgical field we note the continued prosperity and increased

output of the large Southern iron fields, and the practical acceptance of the Virginia New River coal as a standard steam coal of even higher efficiency than the famed Cumberland. In the North the Gogebic iron fields are fast making Chicago the rival of Pittsburgh in the production of iron and steel. But the most important step in practical metallurgy is the successful production of aluminum in Pittsburgh on a large scale at only $2.00 per pound. This brings it into successful competition with steel, copper or brass in many of the more delicate and important parts of machinery, and the day may be near when it will come into general use.

The further development of its many valuable properties may make practical possibilities of many problems of transportation whose realization seems utopian with metals of thrice the weight of this new material.

Turning from the larger horizon to our local circle we may congratulate our friends of the Merchants' bridge on the practical completion of this fine structure, piers, trusses and all, in the limits of a single year. We note also the opening of the Grand Avenue bridge across Mill Creek Valley for traffic; the commencement of the Water Works Extension, which will in less than two years double our water supply at a cost of possibly $3,000,000 and place its source far above possible future contamination by sewage; an energetic and practical movement to convert our water front into a warehousing and manufacturing district with equal facilities for rail and water transportation, and an increase of terminal facilities on the Missouri side of the river; the abolition of the dust nuisance by municipal sprinkling at about one fourth its former cost to individual citizens; an extensive system of subways laid ready to receive the electrical wires whenever municipal legislation applies the axe to existing poles; an extension of our excellent cable railway system, begun later than in more precocious towns, but completed with St. Louis thoroughness, which has given us the model roads of the country; three electric railways running and a fourth, more extensive than all, rapidly nearing completion; brilliant and complete municipal lighting ensured in the near future by three immense electric light plants; work at last actually begun on our elevated railway; and private enterprise, ready to meet the mayoralty's demand for smokeless combustion by furnishing a copious supply of water gas. It being a pre-ordained fact, which no St. Louisan has the heresy to doubt, that we are to have the World's Fair here in 1892, a glance at its probable location must be permitted. The Site Committee found it easy to locate suitable grounds, but the difficulty lies in the final selection of the best out of at least six perfectly practicable sites. Stretching along a line of ridges bordering the valleys, through which the connecting tracks between the five great groups of railways which enter the City must pass, they show an average height of from 80 to 120 feet above high water mark. Their extent is easily double the ground covered by the Paris Fair, allowing for field trials of agricultural machinery, road building and well boring tools, etc., and for that extensive show of cattle and horses, naturally expected of the greatest horse market in the world. Each has large city water mains at its portals, and as we follow the gentle slopes or undulations prescribing natural drainage, we find in the hollows either existing large branches of our sewer system, or the stakes set for them for

next year's work. Compare with this the marshes along the southern shore of Lake Michigan to drain and protect, which Chicago finds it necessary to spend $60,000,000 in the next seven years, and engineering reasons are all in favor of St. Louis as the city of the Fair.

Coming at last to our own Club affairs, I may congratulate the members on having maintained the record as to the number and character of our papers and discussions, some of which, *e. i.*, on the Inter-locking System of signals of the Bridge and Tunnel Railway, on Water Settling, on Chimneys, on Cable Railways, on the Strength of Cable Yokes, and on Street Railway Running Gear, deserve special mention for originality and thoroughness.

The decisive step taken in establishing our own library and reading-room, with a permanent committee looking for better and ampler accommodations to meet the future wants of the club, and the movement begun in the collection of local engineering data, mark an era in the history of the club, and give promise of a larger and more useful future. Three questions of great interest to the profession have been carefully weighed and acted on during the year. First, the proposed establishment of a National Engineering Bureau of Public Works, based on the best ideas of civil service reform, which must ultimately lead to rational legislation on the subject. Second, the means and methods of controlling the erection of highway bridges in the interest of public safety; and third, the subject of closer union of engineering societies. This latter question has been ably discussed, and presented to the most earnest thought of engineers by two of my predecessors in 1886 and 1887, and was forcibly argued by the president of the Western Society of Engineers in Chicago, in 1885. It has, during the year, been partially met in the Association by simple machinery for submitting questions to the vote of individual clubs, and announcing the result, and is now the subject of the most serious consideration by the American Society of Civil Engineers. The selection of the chairman of the committee having special charge of the subject as the official candidate for President of that society, seems to portend favorable action on its part. Our club, and several others in the association, have appointed committees and formulated plans for such union. Local prejudice or interest must bend to this growing demand.

Such union had *best* come through wide and liberal advances from the American Society of Civil Engineers. But it is *certain* to come, in the near future, through some plan of federal union, with individual autonomy of local societies. No matter how frail the first ligaments may be, they will grow to the demands which the interests of an All-American engineering profession will make on them. And we may hope to see finally a federation of civil, mechanical, electrical and metallurgical engineers, co-extensive with our continental limits, making the best efforts of each specialist accessible through its publications to every engineer in the country. The British Institution of Civil Engineers now numbers nearly 6,000 members. If a liberal plan of union, with opportunities for future growth, be adopted, we may soon reach, if not exceed, this number.

The past belonged to the warrior; the present marks the summit of the merchant's glory; the future is the heritage of the engineer.

Let us unite and deserve it!

NOTES ON THE HARBOR FACILITIES OF CLEVELAND FOR HANDLING COAL AND ORE.

BY AUGUSTUS MORDECAI, MEMBER OF THE CIVIL ENGINEERS' CLUB OF CLEVELAND.

[Read January 14th, 1890.]

I wish to preface what I have to say with the remark, that I am not here to advocate any pet scheme, but merely to show you how Cleveland had fallen off in the proportional amount of ore and coal handled the last few years, and ask that you seriously consider the matter and see whether it is not time to increase our harbor facilities. I will leave to Mr. Sargent to suggest a remedy.

The ore trade of Lake Superior has increased wonderfully in the last five years, and the present indications are that it will increase probably in a still greater proportion for the next five years, so that if we can, in any way, entice to this port some of the ore that is going to other lake points, it would seem to be very important and well worth while to do so.

It is true that the labor problem is against us, and it costs a little more for handling ore in this harbor than it does in the neighboring harbors; but that would adjust itself, I have no doubt, if the facilities were equal.

The position of Cleveland, being the most westerly point of easy access to the iron manufacturing districts, would seem to suggest that it should handle the largest amount of ore, since the freight rates by rail are the same from the different points. To some extent it is true that the railroads are to blame; they have not kept pace with the times in their equipment. When we think of the old story, that an ox team can start with a load of ore in Cleveland, and, if it is not stuck in the mud before it gets out of the city limits, it can probably go to Pittsburgh, dump its load and return before the cars leaving Cleveland at the same time would get back, it would seem that there was something wrong with the movement of the car, and this is unquestionably true. The railroads and the furnace men are not handling the raw material as expeditiously as they should: an equipment better adapted for handling ore and coal should be provided, so there would be, without question, each day as many cars unloaded at the furnaces as there are loaded at the docks; for the capacity of a railroad is measured not by the number of cars it can get to haul, but by the number of cars it can get rid of by unloading. This would, of course, necessitate the cooperation of the furnacemen, but if insisted upon by the railroads, I think there would be no trouble in obtaining it.

There are several kinds of dump cars that can be used in this service, and now that the handling of raw material has become such a specialty and cars can be used for that alone and not be required to do miscellaneous

service, I think the the time is not far distant when either the railroad companies themselves or the furnace men, or possibly those new-fangled corporations, the dock companies, may furnish cars especially adapted for this purpose, and will require furnaces to so construct their tracks that the cars can be unloaded promptly and without difficulty.

Mr. Goodwin, of Sharpsville, has lately patented a dump car of very ingenious design. This car will dump its load on either side, in the middle of the track, or any portion of it in the middle and on either of the sides; it is cheap, serviceable and applicable to handle any raw material, in any kind of weather. If this car, or something similar to it, would come into general service, the railroad companies would be able to handle more ore in the season, thereby obviating the necessity of having dumping grounds far away from the dock front.

The transportation of Lake Superior ore to the furnaces of Pittsburgh and vicinity, and to those in the Mahoning and Shenango Valleys, is exciting a great deal of interest. The state of Pennsylvania has appropriated quite a sum of money for the expense of surveying a ship canal from Erie, or some neighboring place on the lake, to Pittsburgh, and though it may have some military value, still the greatest reason advanced for its construction is a peaceful one; and that is that the ships on the lake may carry the ore direct to the furnaces. Of course there are many questions arising about this, that I will not discuss just now, but it only shows the confidence of business men that this trade will continue for a long time, and that the transportation will be an exceedingly lucrative undertaking to any one engaged in it.

This ship canal is projected to leave Erie or some neighboring point on the lake (and, by the way, why not Cleveland) and strike the watershed of the Shenango river; then use the waters of the Shenango river by means of slack water dams to the Ohio river, and thence, up the Ohio river to Pittsburgh.

In writing to me, one of the commissioners says that the first questions to be asked is, "would a ship canal between Lake Erie and the upper Ohio supply more entirely than could any other practicable means—the betterment in facilities for transportation of ore and coal which the situation demands." Second: "Granted that a suitable canal would best supply such betterment, what depth of water should the canal have in order that it may effectively serve the object in view." Again he says: "As suggested by my omission of query in that matter, I am satisfied that, viewed from an engineering standpoint, the project for a ship canal between Lake Erie and the upper Ohio, is entirely reasonable. The supply of water for the summit level is ample; and other conditions are largely favorable to construction." It does seem to me, in considering the first question, that it may be doubted whether a large vessel of 3,000 tons burden, coming down from Marquette, is the most convenient vehicle for the furnaces in the valleys and at Pittsburgh, in which to receive their ore. In the first place, it would require the furnace companies to lay out a considerable amount of money in purchasing land along the canal, or adjoining it, for stocking purposes; also they would be obliged to have expensive machinery for unloading the vessel promptly; and after the ore was unloaded, in many

cases, it would not be near the stock houses of the existing furnaces, and would, even then, have to be loaded on cars and dumped in the stock houses so it would be convenient to the lifts. In the same way with coal, there is a great deal of all rail coal going to Chicago, for the very simple reason that the Chicago yards are not all situated upon the river or the harbor, and prefer to pay the additional cost to get the coal into their yards without additional handling at Chicago.

As regards the second question, it will depend largely upon the size of the vessel that it is proposed to carry in the canal. It would seem to me, that it would add very much to the cost of the canal to construct it for the large 2,000 or 3,000 ton vessels that are now used on the lakes. Take, for example, the bridges over the canal, both railway bridges and highway bridges: it would certainly be necessary, if the canal is to have any amount of tonnage, to build at least the important railway bridges above the masts of the vessels, and this would add very largely to the expense; the same would be true of the important highway bridges, such as those through towns, etc. Then again, carrying such a vessel from the lakes to Pittsburgh, and locking it through the locks would take so long, I am inclined to think that it is a serious question whether the ore should not be loaded in lighters or in large canal boats, which should be propelled by steam, if you will, or possibly by some arrangement on the canals, such as a cable, either in the bottom or overhead. In this way, the expense of constructing a canal would be very much lessened, and the ore could be more readily handled; large stocking grounds would not be necessary, and offshoots from the canal could be built more easily and readily, so as to bring the material nearer the furnace stacks.

The size of the vessels on the lakes has very largely increased in the last ten years. The average size of the vessels carrying ore into Cleveland was at that time not over 800 tons; this season, three vessels brought down 246,500 tons, an average of 2,400 tons a trip each, and their average speed was fourteen miles light, and twelve and one-half loaded per hour. This means that we must have more frontage and a quicker way of unloading. By working eight hatches at Ashtabula, they unloaded one of these vessels in twelve hours, and it is necessary, at all the other lake ports, if we wish to compete with Ashtabula, that we should do as well. Owing to the fact that there is a special line of vessels running between Marquette and Ashtabula, the ore can be unloaded much quicker, for there is always a place for them to go. The rigs are all so spaced as not to require any further moving, and the work of unloading can be commenced at once.

We all know what the port of Cleveland is. Outside of the question of the outer harbor, formed by the breakwater, it is formed by a shallow river, very crooked and crossed by a great many street bridges. It extends two miles up the river, but has no unoccupied ground; 9,000 feet of dock is used for coal, and about the same for ore; 12,300 feet for lumber; 10,000 feet, miscellaneous purposes.

The port of Fairport is a comparatively new one, it is used only on the easterly side, by docks of the Pittsburgh & Western Railroad Company, and these docks are devoted exclusively to the handling of ore and coal. The other side is not docked, except for a short distance, and can be ad-

vantageously used for lake purposes; it is also formed by a river, but the docks run right to the mouth, and, in fact, on the projecting piers; nor is it crossed by a single highway bridge. The port of Ashtabula is formed by a river quite shallow and probably more crooked than the Cuyahoga, but is entirely given over to docks handling coal and ore. On the easterly side are those of the Lake Shore Company, and on the westerly side, those of the Pennsylvania company. They have made use of slips to increase their frontage near the mouth of the river, and the docks do not extend more than a mile up the river. It is crossed by one swing bridge, worked with steam. The hills on either sider are quite high, the valley is not very broad, so that in the summer season, the scene is a very busy and enterprising one.

The port of Erie is one of the best on the lakes. It is formed by an island and the docks are built out from the shore some 2,000 feet or more. The bottom of the lake is rock and there is plenty of water; it does not require to be dredged, and the facilities are excellent for handling vessels; but owing to its more easterly position, it does not handle as much ore as the other ports, for Pittsburgh and vicinity. The rates are somewhat higher to Pittsburgh and the distance is greater. The distance from Cleveland to Pittsburgh, by the Cleveland & Pittsburgh road, is 150 miles; by the New York, Pennsylvania & Ohio and Pittsburgh & Lake Erie, 135 miles. The distance from Freeport to Pittsburgh by the Pittsburgh & Western, is 139 miles. The distance from Ashtabula to Pittsburgh, by the Pennsylvania company, is 125 miles; by the Lake Shore it is 130 miles. The distance from Erie to Pittsburgh is 148 miles. It will be seen, therefore, that the nearest port is Ashtabula. The same may be said of the valley points, that is, to Youngstown and vicinity and Sharon and vicinity, so that, as the lake rate on ore is the same to Ashtabula as it is to Cleveland, and the expense of handling is a little less at Ashtabula, it is not surprising that its facilities have been appreciated and the percentage of ore handled at Ashtabula on the whole amount brought down, has increased so largely in the last few years.

The manner of unloading vessels is very much the same on all the docks on the lake, with the exception of the Cleveland & Pittsburgh road at Cleveland, where they still unload, by a simple hoisting engine and wheel the ore back in barrows. All other docks are equipped with some device similar to the Brown hoisting machine, or the swinging derrick. If you will excuse the possible egotism, I think the New York, Pennsylvania & Ohio docks here are as well equipped as any on lakes, I do not know but better, unless we may possibly except the Pittsburgh & Western docks at Fairport. There they have a number of Brown's Conveying Company's machines, and working underneath and intermediate, swinging derricks. Then, to load the ore that is stocked on the dock, they have a steam shovel. They should handle ore on these docks cheaper than at any other point on the lake of which I know.

In addition to the advantages at Ashtabula in the way of harbor frontage, tbe two railroad companies at that point have trestles made of piles and timber. The Pennsylvania trestle is about a mile from the harbor, and the Lake Shore trestle is about three miles. The ore is handled in

large, three-truck dump cars, holding fifty or sixty tons; in fact, as one of the men told me, "it did'nt make any difference as to the weight, it was only the capacity that they thought about." These cars, after being loaded, are taken by a switch engine and hauled on top of the trestle and dumped. The ore, then, as it is asked for by the furnace companies, is loaded by means of a steam shovel, or by some similar appliance, into the ordinary road cars and shipped to the furnaces. This system of handling ore is not well adapted to Cleveland, as the trestles would have to be built too far out of town, and that would necessitate the expense of running the trains through crowded yards, etc., and increase the cost of handling very

STATEMENT OF RECEIPTS OF IRON ORE AT LAKE ERIE PORTS.

	1883	1884	1885	1886	1887	1888	1889
Total tons rec'd at all points.	1,693,000	1,842,000	1,504,000	2,271,000	3,439,000	3,781,000	5,654,000
Total amount on all docks....	943,000	1,038,000	1,049,000	966,000	1,559,000	1,849,000	2,607,000
Per ct. of amount received....	56	56	70	43	45	49	46
CLEVELAND:							
No. of tons received......	723,000	905,000	589,000	1,035,000	1,216,000	972,000	1,730,000
Per ct. of total am't rec'd.	43	49	39	46	35	26	31
Amount on dock..........	429,000	482,000	495,000	465,000	487,000	528,000	519,000
Per ct. of am't received...	59	53	84	45	40	54	30
ASHTABULA:							
No. of tons received......	670,000	650,000	582,000	672,000	1,104,000	1,289,000	1,956,000
Per ct. of total am't rec'd.	39	35	39	30	32	34	35
Amount on dock..........	292,000	349,000	331,000	286,000	523,000	687,000	1,071,000
Per ct. of am't received...	44	54	57	43	47	53	55
FAIRPORT:							
No. of tons received......	40,000	23,000	32,000	112,000	501,000	611,000	829,000
Per ct. of total am't rec'd.	2	1	2	5	15	16	15
Amount on docks........	15,000	2,000	8,000	7,000	223,000	250,000	390,000
Per ct. of am't received...	38	9	25	6	44	41	47
ERIE:							
No. of tons received......	107,000	116,000	122,000	91,000	210,000	240,000	291,000
Per ct. of total am't rec'd.	6	6	8	4	6	6	5
Amount on dock..........	95,000	78,000	82,000	36,000	89,000	95,000	129,000
Per ct. of am't received...	89	67	67	40	42	40	44

	No. Tons.	No. Vessels.	No. Feet.	Aver'ge Vessel Load.	Aver'ge Ton per Foot.	No. of feet to Cable.
N. Y., P. & O. docks, Cleveland.......	847,000	619	2,760	1,368	307	89
P. P. & F. " Fairport........	826,000	490	5,000	1,686	165	....
L. S. & M. S. " Ashtabula......	1,025,077	....	8,000	....	128	....
Penn. Co. " "	925,000	557	....	1,660	....	....

largely. The necessity of loading by steam shovel from the dock to the road cars could be obviated by having a system of pockets, or, as this would be rather expensive, probably a side hill with a bulk-head at the bottom of the slope with valves in it would answer the purpose better. These valves could be opened and the ore would fall into the car, thus saving the expense of loading. Possibly, too, some arrangement could be made similar to that by which the Lehigh Valley handle the anthracite

coal at Buffalo; there they make a timber tunnel, extending some 500 feet, with valves in the top. The anthracite coal is dumped over this tunnel, covering it completely, and burying it some twenty or thirty feet deep. These valves are opened and the coal runs into the cars, which are quickly and economically filled. The difficulty of putting this arrangement into practice, as regards ore, would be, that the anthracite coal is very much more fluid than the ore, especially in winter weather, when it would be mostly used.

No doubt there will be prompt demand and use for improvements that may be made in our harbor, increasing our facilities for handling ore and coal for some time to come.

Iron is entering into so many places where it was never used before, and where it has been used the consumption has been so enlarged that it seems certain that for the next few years we shall need as much or more per year as we are now making, and then if we have a reaction it will only be temporary.

The growth of the country and the exceptional advantages in Pittsburgh and in the Mahoning and Shenango Valleys, all would go to show that iron will be made there as long as it is made anywhere else in the country. It is, no doubt, true that the iron industry in the south and in the west will increase; but as long as we have the Connellsville coke of such excellent quality, and the Superior ores, the point where the expenses of getting the two together is equal, is the point where the iron will be made, and that point is in the vicinity of the valleys between here and Pittsburgh. To say nothing of other demands for iron, the amount that has gone into buildings has enormously increased during the last ten years, and will certainly continue to increase. It will receive a great impetus beyond the ordinary demand in the exhibits of '92. There were 50,000 tons of iron used in the buildings of the Paris Exposition; 7,500 tons in the Eiffel Tower alone, and it is very reasonable to suppose that in the exposition buildings of 1892, no matter where they may be placed, quite as much iron will be used, and that the tower, ten feet higher, that some enterprising Yankee will build, will not take any less material than that of Mr. Eiffel. Besides we are just waking up to the fact that this great Nation has no navy nor any sea coast defence, and so we propose to say "hands off" to some other nations that are likely to interfere in the canals now building between the oceans. We shall have to have both navy and defenses to make a respectable showing. This means still more iron to be used, increased business at our ore receiving ports, and, of course, more work for the railroads, and withal, an enlarged prosperity for our country.

APPENDIX.

Since the date of the meeting I have received the following letter from Mr. Goodwin which, as it contains valuable and instructive information, I append:

SHARPSVILLE, PA., Jan. 13, 1890.

AUG. MORDECAI, C. E.

CLEVELAND, OHIO.

DEAR SIR:—I learn that you are preparing for reading before the

Engineers' Club of Cleveland, a paper on current practice in handling iron-ore at Lake Erie ports. I hope that you will improve the opportunity offered by the occasion, for making evident (to your hearers at least) the advantages, to the railroads and to the furnace men alike, of delivering stock (ore, coke, lime, stone, etc.) to furnaces, in proper Dump Cars instead of the barbarous and in every way inappropriate "Gondolas" and "Schooners" now generally used in that service. While I say "proper dump cars," I mean to suggest dump cars which will not only dump coke, ore, etc., but will, in lines of traffic where such protection is demanded, protect cargo (as coke for instance) from the weather and from pillage.

My principal object in this letter is to afford you some points relative to the practical utility of a proper four-wheeled car, in which form I prefer to make my dump, the ordinary performance of the modern "big gondola" being taken as a basis for comparison. A proper four-wheeled dump discharging its load between rails or at the side, as desired, occupies in train as extended, 20½ feet of track room. It carries nominally, 30,000 lbs. of ore; on 4″ x 8″ journal it would, in practice, ordinarily be loaded to considerably more than 30,000 lbs. One objection to four-wheelers, in this part of the country, has been that they do not carry (per foot of train) as much as eight-wheelers. The 60,000 lbs. gondolas stand 36 feet in train, extended, and were they loaded to their nominal capacity, one of these cars would carry 1666⅔ lbs. to the train foot. My car, 20½ feet in train, carrying 30,000 lbs. would carry but 1463 lbs. per foot. But in practice the big gondolas, 50,000 lbs. and 60,000 lbs., running together cannot, or do not, carry up to even the 50,000 lbs. figure. My dump body will carry safely all that the journals under it will carry; while we find that, in practice, the gondola-body does not (presumably because it cannot) carry its nominal load, or the load which the journals under it might safely carry.

A certain lot of gondolas, 101 in number, loaded with ore from Ashtabula, in October, 1889, carried (average) load of 39,165 lbs. each, a total of 3,955,665 lbs. or 1,977.83 tons. They occupied 3610½ feet in train and carried 1,095.6 lbs. per foot of train on 808 wheels and 404 axles. A train of 177 Goodwin dumps (20½ feet in train) would occupy 3,628½ feet of track; and on 708 wheels and 354 axles, would carry 5,310,000 lbs. of ore, or 1,463.4 lbs. per train foot, an aggregate load of 677.17 tons greater than that carried by the 101 gondolas and schooners.

Anticipating that the 101 (one-hundred and one) cars were, probably, not doing the service ordinarily performed by cars of their class, I add the fact that of 9,509 eight-wheeled cars of various modern styles received at one establishment in the Shenango Valley, in 1889, carrying furnace stock and supplies, ore, limestone, coke, sand, clay, firebrick, etc., and presumably loaded, in each instance, to the extreme allowed limit, the average cargo was 38,008 lbs., or 1,157 lbs. less than the average load of the 101 (one-hundred and one) cars; and of 3,014 cars loaded out from said establishment, in 1889, with pig metal and muck bars, or blooms, the average load was 38,705 lbs., or 460 lbs. less than the average load of the 101 cars.

Of a group of 181 gondolas and schooners coming, in 1889, with ore

from Erie, Ashtabula and Cleveland, respectively, the average load was 39,041 lbs. Of these 181 cars, 50 carried average loads of 34,218 lbs. only and these kept the general average down; but the lot of seven of the 181 cars, which carried the heaviest loads in the whole group, did not average as high as 50,000 lbs. per car. These 181 cars occupied in train, at least 6,470½ feet of track; they had under them 1,448 wheels and 724 axles, and carried an average of 1,092 lbs, per train foot.

Two hundred and thirty-five (235) Goodwin dumps with 940 wheels and 470 axles, occupying 4817½ feet of track, or 1,653 feet less than the 181 eight-wheelers, would carry the aggregate load of the 181 cars.

Counting the cost of unloading the gondolas at 5 cents per net ton, the outlay for discharging the 181 cars was $176.66. The dumps would unload themselves without appreciable cost. And moreover, one-half the outfit of the dumps, that is to say 118 dumps would, in this ore trade, perform a considerably greater tonnage service in any given period, of say ten days or thirty days, than the gondolas ever did or ever will perform. This latter proposition you can support from facts in your own knowledge.

Now allowing that a 50,000 lbs. gondola may be had to-day for $350; then the 181 cars represent an outlay of $63,350. Allow that a dump cost as much as a gondola, which it does not, then the 118 dumps would cost $41,300, and in endurance and servicable qualities generally in the lines of traffic for which they are designed, the dumps are largely superior to any eight-wheeled gondola. The objection that four-wheeled cars are not as "road-worthy" as eight-wheelers is not, in any regard, well founded. A four-wheeler, with 9 feet or 9½ feet wheel base runs steadier, tracks truer and hauls very much more easily than any eight-wheeled, two truck car. The idea that a four-wheeler of 9 or 10 feet wheel-base will not readily track on curves, such as are found in our railways. is absolutely without foundation in fact.

The standard freight car of the German State Railroads, rated to carry about 12 tons, net, is a four-wheeler, having 13.1 feet wheel-base.

In this country there are more than 100,000 four-wheeled freight cars in service. One company has more than 27,000 such cars in service; another has something more than 25,000 such cars, but they are small affairs compared with my standard gauge dump, which with M. C. B. fittings and lined throughout with 3/32″ steel plate, weighs about 15,000 lbs., and is rated to carry 30,000 lbs. of ore. The latest style of dump carries 12½ net tons of lump coal, bituminous. The drawheads stand at M. C. B. height, 2′ 9″ above rail; and the draft line is mid-high of the sills of cars.

Two (2) timbers 4½″ x 10″, extending from end sill to end sill, take the shock of buffing impact.

Five of my dumps have been in service for four (4) years, hauling and distributing along the road furnace cinder taken hot from the cinder bed. They have made, each, two trips per diem (Sunday excepted) throughout the whole period named; averaging 14 miles out, loaded. 28 miles per round trip; 56 miles per diem; 17,528 miles per year; 70,112 miles in the four years. Have carried 10 tons cinder per trip, 20 tons per diem; 6,260 tons per year; 25,040 tons in the four years; 25,040 tons carried

14 miles = 350,560 ton miles, per car. In the four years the five cars have haudled and distributed along track, 125,200 tons of cinder. Each car made 280 ton miles per diem, right along.

You know from your own investigations, made in February, 1887, that the average gondola car in ore trade between Cleveland and the Shenango Valley, makes total travel of about $13^{37}/_{100}$ miles per diem; and makes, in a period of thirty (30) days, 2.39 round trips. It carries, say 17 tons of ore per trip out from Cleveland. Of 50 cars from Cleveland, lately noted by myself, the average load of ore was no more than $15\frac{285}{2240}$ gross tons. We will say that it has one back load of pig metal, of 17 tons. Then in 30 days time, it would make 401.1 miles travel and 4,826.64 ton miles.

For each wheel-mile the gondola made 1.5 ton miles; the dump 1.25 ton miles. But having credited the gondola with tonnage beyond its capacity, in practice, we should now credit the dump with 30,000 lbs. (13.393 gross tons) for each load carried in the actual run which we are considering. This being done we have, for dump $\left(\frac{1680}{2} \times 13.39\bar{2} \text{ tons}\right) =$ 11,250.12 ton-miles; and making 6,720 wheel miles, as it did, it makes 1.67 ton-miles per wheel mile.

In the trial service, of 31 days, to which one of my dumps was subjected, under your supervision, in January and February, 1887, the dumps, although held for experimental dumping, etc., some nine days or about 30% of the whole period, made 4,434.7 ton-miles, with 504 miles of travel, and 2,016 wheel miles. It therefore made 2.19 ton-miles per wheel mile, while the average gondola in service with the dump during the period of 31 days, made no more than 1.35 ton-miles per wheel mile.

Yours truly

J. M. GOODWIN.

CLEVELAND LOOP-LINE RAILWAY AND HER MAGNIFICENT OUTSIDE HARBOR.

BY JOHN H. SARGENT, MEMBER OF THE CIVIL ENGINEERS' CLUB OF CLEVELAND.

[Read January 14, 1890.]

Half way back to the beginning of this remarkable nineteenth century, I found myself climbing the Alleghenys over Cleveland's newest acquisition, the Baltimore & Ohio railway.

This was then a great through line, for the time being terminating at Cumberland, and was the leader in American railways. It was railed with the "U" rail, and they had just learned that rails laid upon solid stone sills were soon pounded out even by the light cars of that early day: these discarded sills were yet lying along the track.

Half way from that day to this, I was at the "Future Great," locating a railway from Toledo to a junction at Crestline, with what is now the Pennsylvania Central and the Big Four. I remembered the Baltimore & Ohio, and made strong efforts to induce the company to take hold of the project and extend my line from Crestline to Lexington on their Lake Erie branch, without avail, and the great Pennsylvania swallower gathered the fruit.

In passing, I must bear testimony to the penetration and forethought of my old friend, Jessup Scott, who christened the "Future Great." He clearly saw a future great city upon the lakes, but self interest led him to locate it at that somewhat retired corner of Lake Erie—Toledo. Later developments would have led him to locate it where the north end of West River street in Cleveland now is,—the focus of the five or six great thoroughfares. Here the New York Central, the Pennsylvania Central, the New York, Lake Erie & Western, the Baltimore & Ohio, the Big Four and the Lake Shore meet centrally the many thousand miles of internal navigation, leading on the one hand to the Gulf of St. Lawrence and the North Atlantic, and on the other, through Chicago's grand sewer to the Mississippi, the gulf of Mexico and the South Atlantic. Providence (Providence is a better term than fate or accident) had some design in bringing successfully all these great trunk lines together at this point. It is my purpose, in this paper, to assume the role of an interpreter and pry into this design of Providence.

For unknown centuries the waters of Lake Erie have been wearing away the sand and clay of the banks of Cleveland Bay, in fact forming it, until now along the shore is a shoal, and you get out about a quarter of a mile before you get into fifteen feet of water. This shoal is just the space required, and is just in the right place to accommodate the trade of all these great thoroughfares. This space should be docked and filled progressively in say blocks of fifteen acres, giving more than a half mile of dock front to each block, with eighteen feet water, or more, if desired. West of West River street may be thus recovered one hundred acres inside the break-water, and west of the latter, one hundred acres more, if desired, to the point where the Loop line I am about to describe, leaves the shore.

This Loop line should be built by a combination of all the roads interested, that all may have a joint use of it. Beginning at the common point, the north end of West River street, it runs westerly as projected along the shore of the lake to a point about three-fourths of a mile west of the breakwater; here it curves to the south and passing under Lake avenue, it crosses the Nickle Plate railway at grade near where the latter passes under the Lake Shore & Michigan Southern railway; thence under Detroit street, Madison avenue, Lorain street and the Big Four railway at Lynndale. Here it will connect with the Big Four and the prospective Cleveland Southern railway. (Just here, by way of parenthesis, I wish to say a word for the "Cleveland Southern." In five miles from the lake front it encounters an extensive bed of fine quality Berea Grit and skirts it for some miles; in thirty miles it encounters the first coal; in less than forty miles it crosses the New

York, Pennsylvania & Ohio, forming with that road a grand loop line of its own, and thence on to the Perry county big coal veins, it is skirting mineral all the way, and bringing Perry county within 150 miles of our great "focus.") Thence the Loop line runs down Big Creek Valley to its mouth and there connects with the Baltimore & Ohio road and through it, completes the loop to the starting point. By throwing out a spur up the valley of Buck Brook or parallelling the Cleveland and Canton, we reach the industrial establishments of the iron ward and the railways centering there. In this way, all the industrial establishments of the Cuyahoga Valley are connected with the outer harbor and through it, with the navigation of the globe.

One beauty of this Loop line is, that from the river's mouth around to the up river valley, not a single street or railway is to be crossed at grade, with the single exception of the Nickle Plate, which exception is of great value to that road, as the Loop will connect it with the outside harbor and with the industrial establishments of the city.

The citizens of Cleveland are finally getting their eyes open to the importance of this outside harbor. A strong point of it is that its improvements may be made progressive and as each block is constructed it may be leased so that its rental will at once pay a good interest and sinking fund to finally liquidate its cost.

An Eastern extension may be carried across the river and along the shore of the lake to Gordon's Park and beyond if desired, and be lined with industrial establishments, always excepting the lake front of Lake View Park and the Marine Hospital grounds, which should be devoted to the pleasure, cleanliness, recreation and education of the public.

West of where the loop line leaves the lake front the land as far west as Jacob Perkins' residence is well calculated for a picturesque park; it has a broad valley reaching down to the water's edge, where an ample beach may be formed. This, with Lake View Park and Gordon's Park, will furnish *our* "Future Great" with ample means of enjoying the beautiful waters of Lake Erie. Although this fact may not pertain exactly to railway engineering, it will be an attraction to draw the outside public over all the railways centering here, and business is quite as essential to railways as their rails.

The cost of filling and docking a block of fifteen acres may be set down as between the somewhat wide limits of $75,000 to $100,000. The loop line will occupy 100 feet in width of the shore end of it and will share in the expense. We then have left fifteen acres of land, with 2,400 feet of dock front, besides 600 feet of bulkhead. Let us now assume $6,000 a year for interest and sinking fund as an annual rent, or $2.50 per foot front of dock 300 feet deep, or less than 1 cent per square foot annual rent, with no towage, no delays from drawbridges or blockades, gorges or running of ice, or cost for dredging, since, in filling the docks, the slips can be profitably dredged to twenty or more feet of water, and there will be no currents to carry in sand.

In my opinion the way to accomplish this is for the city of Cleveland to form a dock commission like New York's and get from Congress and the State Legislature authority to issue bonds to reclaim this land under water,

to build docks and wharves and lease them to all who will use them, pledging the rent to the redemption of the bonds. If there are any adverse interests beyond the shore line, which is very doubtful, the city can appropriate them.

The Loop-line road, by its charter, should be required to take the cars of all railways now and hereafter connecting with its line to and from these city wharves upon just terms. West of the river and inside the breakwater may be recovered six blocks, with an aggregate of sixteen to twenty thousand feet of dock front, just where it is most acceptable to lake commerce, where ore, coal, stone and all kinds of lake freight may be exchanged with the railways.

Cleveland is essentially a child of the Nineteenth century; at the beginning of this last decade it has just entered upon its second quarter-million, and is increasing at a rate that is almost sure to accomplish its half million by the close of the century. It took two decades to get its first quarter-thousand and less than nine decades to accomplish its first quarter-million. What may we not expect for the remaining ten years? The writer has seen this transition from a quarter-thousand to a quarter-million. What may not the younger members of this club expect to see before their locks become as white and thin as his?

With a direct, independent trunk line of railways reaching from each of the great cities—Boston, New York, Philadelphia, Baltimore, Chicago, St. Louis and Cincinnati, meeting right here upon our lake front, with our magnificent and rapidly increasing fleet of 3,000-ton steel steamships, who can doubt the growth of this place? Hence the importance of building for and looking to the future.

Many of our *patriotic* citizens having grown fat upon Cleveland's undeveloped advantages, have taken their shekels to build up Chicago, Toledo, Lorain, Fairport and Ashtabula instead of directly advancing the interests of their own home, as its superior advantages invited. However they have but built up tributaries to Cleveland, while new blood and new capital is stepping in with increased faith and energy to carry on the work. Engineers of Cleveland, your field of usefulness is widening and demands your deepest thought and strongest energies. In conclusion I beg leave to call up before you three or four of the earliest engineers engaged in starting these great trunk lines. First came Cyrus Williams, who, in 1840, was building along the lake a broad gauge railway as a continuation of the New York & Erie. But the project was a little ahead of its time, and people said, "It is an insult to the Almighty to build a railway along Lake Erie," so the scheme languished and died, as did good old Cyrus Williams. Then came Frederick Harbeck ten years later and revived the project, and when completed it became a part of the New York Central. At the same time he pushed through the C. C. C. & I., part of what is now the "Big Four." His head was too active for his frail body, and he died early; "whom the gods love," etc. Then came my old rodman, J. H. Devereux. His financial skill and superior administrative ability soon took him—shall I say above, at least—beyond the field of engineering; but he did much to perfect what is now the Lake Shore and the Big Four. Next came an erratic Englishman, Thomas Kennard, who thought to give Cleveland

the go-by by taking the Atlantic & Great Western thirty miles south of us. This was of itself a failure, but the company had a little good sense, and gobbled the best bit of road in this region, the Cleveland & Mahoning as a branch, and the branch kept the life in the decaying body until now it has become a part of the New York, Lake Erie & Western, under the lingering title of the N. Y. P. & O.; but Kennard went to—New York.

Gentlemen, I thank you for your patience under my somewhat rambling discourse.

SOME POINTS IN BRIDGE INSPECTION.

By Henry Goldmark, Member Engineers' Club of Kansas City.

[Read May 20, 1889.]

The Engineers' Club of Kansas City, perhaps the youngest of local technical societies, has taken the lead in at least two important reforms with regard to bridges.

Prof. Waddell's pamphlet has undoubtedly directed the attention of the profession to certain needed improvements in highway bridge building.

Changes in a matter of this kind are of necessity slow, but the active discussion aroused by this paper, will doubtless bear fruit in giving us better bridges in the future.

The second question in which our club has played to some extent the part of a pioneer is perhaps of even more immediate importance. I refer to its agitation for state control over existing structures.

We may not all agree as to the best method by which unsafe bridge-spans can be found out,—nor under whose authority necessary changes should be made—but that some central control is imperatively needed will not be denied by anyone conversant with the subject.

The bill which is now before the Missouri legislature has been for various reasons, confined to road bridges. I am not inclined to undervalue the importance of providing safe transit for carriages and foot passengers. From what little I have seen of highway bridges, east and west, the room for improvement in this direction is very great.

Far more important however in my opinion is the kindred question of safe railroad bridges. In the magnitude of interests involved, the number of human lives endangered, the value of property exposed to risk, the structures on our main railway lines, call for far greater care than on our less frequented streets and highways.

Railroad travel involves at best numerous risks and dangers. Some forms of accident undoubtedly inhere in this means of conveyance. Broken axles and rails will hardly ever be entirely wanting among the

causes for fatal accidents. Human care and intelligence has its limits and even the most improved methods of signaling will hardly do away entirely with collisions and derailments. As a matter of fact inventive intelligence of a high order is at work night and day striving to lessen these inevitable risks.

The so-called *permanent* structures of the road, as distinguished from those parts on which there is necessary wear and tear, should be as far as possible entirely free from the danger of sudden failure.

In point of cost and magnitude the bridges of a railroad are beyond doubt its most important structures. In its present development and application to long spans bridge building is one of the proud achievements of engineering. A Brooklyn or a St. Louis bridge is rightly considered a great triumph of human intelligence and skill. Whatever improvements the future may bring forth these early long spans will remain standing for many years to do credit to the engineers of their generation.

It is doubtful whether as much can be said of the majority of the shorter but scarcely less important bridges which are to be found by the thousands along our railway lines.

I do not refer in this connection to the very general use of trestles as a simple measure of economy in place of masonry culverts. There is not much to be said against trestles as now generally built, as far as strength is concerned but they are of wood, need careful watching and frequent renewal, besides being in constant danger from fire.

What I wish to refer to paticularly is the fact that in our shorter spans, say up to 150 feet in length, we do not seem to have reached anything that can be fairly called a permanent structure.

Apart from the increased train loads, I do not think it can be denied that bridges built even five years ago now seem to contain faults absolutely fatal to a long life.

I do not mean simply that we are building *better* bridges to-day—but more than this—that not a few bridges considered very good practice five years ago need renewing now from inherent defects.

What the exact condition of the railway bridges throughout the country actually is, is a matter difficult to ascertain.

On our one hundred and fifty thousand miles of road, there are many thousands of such structures, of which no report or examination has ever been made. Built at various times with little or no intelligent supervision, nothing is heard of such bridges until a so-called bridge accident calls public attention to the matter.

Wherever a systematic examination has been made, an alarming state of affairs has been found to exist.

The state of Massachusetts, two years since, required all railroads within its borders to submit to the railroad Commissioners plans and strain-sheets of all bridges over ten feet in length. There are of such bridges 1,619 on the 5,000 miles of road in the state. The same proportion throughout the country would give nearly 50,000 on all railroads in the United States. That such examination was needed is proven, apart from the state inspector's report, by the fact that "193 bridges or about twelve per cent. have been rebuilt since the passage of the act of 1887, while about 125 others have

been repaired and strengthened—making a total of nearly twenty per cent."

The present writer's experience, as far as it goes, tends to corroborate the above evidence, as well as the similar experience of the New York commission.

The reasons for this state of affairs, are, in my opinion, the following:

First. Too great economy in first cost of bridges.

Second. A total separation between the engineers who build the bridges and the road-masters or superintendents who use and take care of them.

As to the first point, the practice of competitive bidding on both designs and manufacture has a great deal to answer for. Close competition has, doubtless, done much to develope American bridge building.

The pin connected bridge, as a type, has been envolved in the struggle. It is admitted by eminent English engineers that eye-bars and pins are the proper forms for large and long spans. I am inclined to believe they will be adopted before long for these purposes, even in Europe.

On the other hand, it must be admitted, that pin connected bridges, as applied to short lengths, say of less than 125 feet are out of place. They were and are the cheapest forms which can be built to fill certain specifications—but filling a specification and carrying a sixty ton engine at the rate of fifty miles per hour are two entirely different things.

Hundreds of bridges have been designed and built in which the static strains agree perfectly with severe specifications, which are, nevertheless, quite unfit for the work they have to do.

Questions of import were entirely neglected. The conditions under which the bridge is used is not taken into account, and the whole framework, though correct as a paper design, does not stand the test of experience.

The blame for this does not attach to the designing engineer who builds, nor to the road engineer who buys the bridges. The trouble is indicated in the second reason mentioned above, viz.: That the bridge builder *very rarely* has a chance to see his bridges after they leave the shop. And that the road-master or the railroad company's engineer is seldom enough of a specialist to fully understand bridge work, and, moreover, is often not consulted as to new work that is to be done.

A reform is here needed, and has, to some extent, begun. Many railroad companies have found it to be to their interest to put the general supervision of their new bridge work into competent expert hands. Even with the most reliable contractors it is no more than a wise precaution to have designs carefully examined and checked over.

The best firms do not of course object to this supervision—but often find it to their advantage.

Inspection in the mill and shop has become general. What is needed in this direction at present is a more complete supervision of the bridges that are in actual use by special engineers devoted to this branch of work.

Large systems could well afford to employ an engineer for this special purpose. But even smaller roads could easily secure the advantage of expert examination at small expense, by making arrangements with consulting engineers of known reputation, who need devote only a portion of their time to each road.

I would lay particular stress upon the necessity of having such care systematic and continuous. It should in my opinion be organized in such a way that a complete record of each bridge could be referred to at any time. This may seem to be almost a matter of course. Practically very few American roads have any complete set of plans in their possession.

The first thing then is to get the information which will enable us to make fairly full plans. With most lines the routine will be as follows:

First. A very complete examination and the preparation of drawings and plans.

Second. A correct calculation of strength and stiffness for the engine and train loads in use.

Third. Careful observation of the bridges under passenger and freight trains, at different rates of speed.

The vertical as well as the lateral deflections and oscillations should be noted.

Besides this, any parts which do not appear to take the strain, which they are intended to carry, should be marked on a diagram and all rivets tested.

While the naked eye will usually be a sufficient guide, it is often of advantage to use the plummet or the transit to test horizontal or vertical alignment.

Joints in abutting surfaces in chords and posts should be closely watched and any weak points, whether they can be at once remedied or not, should receive special attention. Examinations of this kind will prove of great interest and value to the engineer who makes them, as well as to his employes. They will indicate very many points which can be improved in future work and which no amount of study at the desk would have suggested. Faulty details and connections will be made evident and can be avoided.

Knowing the ground intimately, the bridge engineer will be in a position to judge intelligently which structures, though not quite up to modern practice, may safely be continued in service and where on the other hand a new span is needed.

He will take into account the location of each crossing with reference to grades and curves as well as the frequency and direction of the traffic.

He will be able to judge each case on its own merits and advise as to the best course to pursue. In this way—combining theory and practice—by learning from the mistakes of others as well as our own; taking advantage of improved materials and cheaper methods, we may hope some day if not now to attain the object of our study, that is, to build a railroad bridge which shall safely do its work for a long term of years, and be practically if not absolutely what it should be—a truly permanent structure.

ASSOCIATION OF ENGINEERING SOCIETIES.

PROCEEDINGS.

WESTERN SOCIETY OF ENGINEERS.

DECEMBER 4, 1880.—The 264th meeting of the Society was held at its own rooms, Wednesday evening, December 4, 1880. In the absence of the President, Mr. Benezette Williams, Past President, was called to the chair. The Secretary read the minutes of the last meeting, which were approved, and also a report of the last meeting of the Board of Directors, at which the following gentlemen were elected to membership: Messrs. James L. Armstrong, Geo. E. Dixon, Frank Herdman, W. E. Williams, O. E. Winger, W. H. Wissing, Robert H. Yeats, John L. Van Ornum.

The Chairman then called upon Mr. John H. Gregg for his paper on "Transmission of Power by Manila Ropes."

In opening his paper the author remarked upon the recent introduction of Rope Transmission and its sudden popularity, due to adaptation to American ideas and the growing dissatisfaction with belts. The English system employs independent ropes—one to each groove in the sheave. The American system employs one continuous rope, independent of the number of grooves in the sheaves, and provides an automatic tension carriage for taking up the slack in the rope. Two kinds of sheaves are used, drivers and idlers. The groove for driving sheaves, in most general use, is one in which the included angle is 45°. The ropes are not allowed to bottom. The grooves for idlers is semi-circular. The author quoted a number of advantages obtained by this system. The power transmitted depends on the size of the rope and its velocity.

The author briefly described some of the details of the plants now running in Chicago and elsewhere, and showed wherein the difference existed in examples of both English and American practice. A number of drawings of various plants were introduced.

The ropes used for transmission purposes are made from the best quality of Russian hemp laid in tallow. The rope should be hard, but pliable and perfectly smooth to the touch, with no rough or loose ends. The color is yellowish gray—black spots indicate fermentation in curing. It should be laid up in three strands, on account of being easier to splice and with less of the rope to cut away to make the splice.

The average breaking strength of the manila rope is 10,000 pounds per square inch.

In the discussion which followed Mr. W. E. Williams asked whether any difficulties had been experienced by reason of variation in the diameters of the various grooves, and the effect of such variation; in reference to pulleys, and the effect of adhesion of rope on pulley, whether the pulley ever happened to be introduced so small as to be incapable of utilizing the whole of the working power of the rope. He also enquired regarding the power formula for ropes, and its relation to that for belting.

Mr. Gregg replied in regard to variation in diameter of grooves that it was disastrous to the efficiency of rope transmission, but that in practice all the grooves are made accurately to a templet. The limit of the smallest diameter of the sheave is thirty times the diameter of the rope, which has proved reliable. The formula for rope transmission is entirely empirical. He knew of no valuable experiments, and he did not believe any had been published.

In reply to questions of Mr. O. B. Green, Mr. Gregg said: The adhesion of the manila rope was on its sides and not on the bottom. Wire rope was only used on

straight drives. The rule for wire rope was that the sheave should not be less than 120 times the diameter of the wire, where a small wire rope was used to transmit a large amount of power.

In reply to the Secretary, Mr. Gregg explained the method of laying out a small plant, and in reference to the durability of manila rope he said, that rope transmission in this part of the world was a new thing, but that he had ropes that had been running for three years which were good as new, and according to some English reports, ropes lasted from three to five years, with isolated cases showing twenty years use. All transmission ropes are treated with tallow, while for outside use, the manufacturers have a special treatment. One of the disputed elements in the problem is the loss by friction as compared with other methods of transmission He hoped to be able at a future time to give the Society the result of further investigations.

Mr. O. B. Green mentioned some cases under his observation where rope for heavy loads was being used over very small drums.

Mr. Gregg repeated that the rule for driving sheaves with rope transmitting power should be 120 times the diameter of rope.

Mr. Liljencrantz mentioned a case of a ¼ inch wire rope over a three or four feet pulley transmitting power for about a quarter of a mile to a threshing machine, with pulleys 300 feet apart.

Mr. Gregg said wire rope was used very extensively in the North, but that manila rope was fast transplanting it, and that manila rope had longer life than the wire. He had seen wire rope used for transmitting power with pulleys 400 feet apart without intermediate support. No tension carriage is required with such long distances with manila, the manila slack takes care of the tension.

Mr. Cooley mentioned a long distance drive at Lockport, N. Y., perhaps half a mile. Mr. Gregg said he would try it should the problem be put to him.

A number of questions of detail were asked as to material for sheaves, shape of grooves, difference in cost, and relative sizes of wire and manila rope for same power.

Mr. Gregg closed the discussion by saying that iron was the best metal for sheaves, that the groove was V shaped with an angle of 45°, although in one instance where he was under conditional circumstances he had used a groove of about 24°, the rope must never bottom. As to price he thought wire was listed at eight cents and manila rope at five cents. In a plant he put in where a ⅝ wire rope, running 5,000 feet per minute transmitted 100 horse power, for manila rope he should use diameter 1¾ inch. He understood that the use of a single rope was an entirely American idea.

The chairman next called for a report of the "Committee on Nomination of Officers and Annual Meeting."

Mr. Lundie for the Committee reported the following nominations for officers for 1890:

President, O. Chanute, L. E. Cooley; First Vice-President, Robt. A. Shailer, R. Forsyth; Second Vice-President, J. F. Wallace, W. R. Northway; Secretary, Treasurer and Librarian, John W. Weston; Trustee, Benezette Williams, A. Gottlieb.

With regard to annual meeting Mr. Lundie said that, after canvassing the matter pretty well the Committee had set the 8th of January as the date, and proposed that it be held at Kinsley's. The Committee also recommends that the Board of Directors invite such guests of prominence as they may deem proper.

Mr. Liljencrantz explained in reference to nomination for officers, that he had some time since handed in his resignation to the Board of Directors which had been received.

The Secretary explained certain views of the Board as to the annual meeting, the arrangements of the Committee being thoroughly in accord with their ideas.

The subject of the President's address will be "Important Engineering Works recently Built, now Building and Projected," illustrated by stereopticon views.

The report of the Committee was approved and the Committee continued to carry out the programme.

Adjourned.

JOHN. W. WESTON, Secretary.

MONTANA SOCIETY OF CIVIL ENGINEERS.

DECEMBER 21, 1889.—The regular monthly meeting was held at the office of Mr. E. H. Beckler, Chief Engineer Montana Central Railway. President B. H. Greene in the chair. In the absence of the Secretary Mr. George O. Foss acted in that capacity.

The following committee of arrangements for the annual meeting was appointed: Messrs. E. H. Beckler, F. L. Sizer and George O. Foss, of Helena; Mr. E. H. Wilson, of Butte, and Mr. G. H. Robinson, of Marysville.

The nominating committee reported that the following names had been submitted to the Board of Trustees for officers for 1890:

For President, Elbridge H. Beckler, of Helena; for 1st Vice-President, John Gillie, of Butte; for 2d Vice-President, John Herron, of Helena; for Secretary and Librarian, Charles G. Griffith, of Helena; for Treasurer, Albert S. Hovey, of Helena; for Trustee for three years, Adelbert E. Cumming, of Helena.

Adjourned. J. S. KEERL, Secretary.

JANUARY 11, 1890.—A special meeting was held at 8 p. m. at the office of the Chief Engineer Montana Central Railway. First Vice-President E. H. Beckler in the chair. There were present Messrs. DeLacy, Griffiith, Pearis, Foss, Helmick, Hovey and Keerl.

The chair stated that the meeting was called to take suitable action in respect to the death of the Society's late President, Gen. B. H. Greene, and to determine a programme for the annual meeting that will be in accord with the Society's bereavement.

After a discussion at some length relative to the propriety of adopting the resolutions common to such occasions the following motion by Mr. Griffith was carried: "That the chair appoint a committee of three to prepare a memorial of the life of Gen. B. H. Greene, and that the committee report at next meeting an approximate cost for printing the same in pamphlet form, with lines of double spacing, including a steel plate likewise of the late President for a frontispiece."

The chair apppointed as such committee Messrs. J. S. Keerl, Col. W. W. DeLacy and W. A. Haven.

Mr. Foss of the committee on arrangements for the annual meeting stated that the programme as arranged provided for the business meeting on January 18th, an excursion by special train to the mines and mills of the Montana Company at Marysville, and a banquet at the hotel "Helena" on the 20th inst. On the 21st the programme included an inspection of the Helena waterworks and an excursion by special train to the East Helena smelter.

It was the unanimous sentiment of the meeting to forego and postpone indefinitely all festivities at the annual meeting, and the committee on arrangements were instructed to abandon all the special features of their programme as a token of respect and esteem to the late President. The Secretary was instructed to convey this sentiment of the meeting in his call for the annual meeting.

Adjourned. J. S. KEERL, Secretary.

THIRD ANNUAL MEETING, January 18th, 1890.—First Vice-President E. H. Beckler, Chief Engineer Montana Central Railway, called the meeting to order in his office in the Montana National Bank Building. There were present, Messrs. Haven, Foss, Sizer, Keerl, Pearis, Wade, Wheeler, Helmick and Tappan, of Livingston, and visitors Bickel and Brown:

The minutes of the two previous meetings were read and approved.

Applications for membership were received from F. D. Jones, O. C. Dallas, J. L. Buskett and Finlay McRae, which were ordered filed and the Secretary instructed to mail letter ballots to all members of the Society.

The Committee appointed at the special meeting of the 11th inst., to prepare a memorial to the late President of the Society, reported they were in correspondence with General Greene's relatives and associates in different parts of the country, and also furnished an estimate of the cost of the steel engraving to be used as a frontis-

piece in the printed memorial. On motion of Mr. Sizer the Committee was continued with power to complete the work in hand.

Mr. W. A. Haven, Chairman of the Committee on affiliation with the American Society of Civil Engineers, reported that he had been unable to attend the meeting of the Board of Managers of the Association of Engineering Societies held in Chicago—notice of said meeting not reaching him in time. He stated that he had interviewed Mr. Bogert, Secretary of the American Society of Civil Engineers, while in New York and was pleased to be able to report that assurances had been given him, that the Society's receipt for the celebrated Punch would be furnished, should the affiliation be accomplished.

On motion of Mr. Pearis the Committee was made a standing one.

On motion of Mr. Keerl, Mr. Haven was voted the sum of thirty dollars ($30) to cover the expenses of his trip.

The reports of the Secretary and Librarian and Treasurer for the year 1888, hav-already been approved by the Trustees and not previously acted upon by the Society, on motion of Mr. Sizer were formally approved.

Mr. Sizer was appointed the third member of the Committee on National Public Works to fill the vacancy caused by the death of General Greene; Mr. Haven succeeding to the Chairmanship of said Committee.

Mr. J. S. Keerl, Secretary and Librarian, read the following report for the year ending January 18th, 1890:

ANNUAL REPORT OF THE SECRETARY—JANUARY 18TH, 1890.

To the President and members of the Montana Society of Civil Engineers:

GENTLEMEN:—I have the honor to submit my report as Secretary and Librarian of your Society, covering the period since my last report, dated January 19th, 1889, to this 18th day of January, 1890.

RECEIPTS.

During this period, the amounts paid to me as Secretary have been as follows:

Initiation fees from seven members at $5	$ 35 00
Semi-annual dues for first half of 1888 from five members at $2.50	12 50
Semi-annual dues for second half of 1888 from nine members at $2.50	22 50
Semi-annual dues for first half of 1889 from forty-two members at $2.50	105 00
Semi-annual dues for first half of 1889 from one member on account	1 50
Semi-annual dues for second half of 1889 from thirty-five members at $2.50	87 50
Semi-annual dues for first half of 1890 from four members at $2.50	10 00
Semi-annual dues for first half of 1890 from one member on account	1 00
Assessment on account of Executive Board of the Council of Engineering Societies on National Public Works, at $1.00 per member from four members	4 00
Total receipts	$279 00

This amount has been paid to your Treasurer, Charles W. Helmick, Esq., vouchers for sum being here attached.

EXPENDITURES.

Orders have been drawn on the Treasurer, covering the following distributions:

For Assessment account Association of Engineering Societies	$ 163 00
For Printing and Stationary	113 60
For Books for the Library and binding	84 25
For Incidental expenses of Committee of Arrangements, Second Annual Meeting	22 40
For Clerical services rendered Committees and Secretary	25 75
For Incidental expense account of Secretary	30 05
For Pillow of Flowers for President Greene's Funeral	25 00
Total Expenditures	402 05
Leaving balance in Treasury	69 50

DUES UNCOLLECTED.

Two members are delinquent for first half of 1888 at $2.50	5 00
Four members are delinquent for second half of 1888 at $2.50	10 00
Eleven members are delinquent for first half of 1889 at $2.50	27 50
One member owes balance for first half 1889	1 00
Twenty-two members are delinquent for second half 1889 at $2.50	55 00
Fifty-two members are delinguent for first half 1890 at $2.50	130 00
One member owes balance for first half of 1890 at $2.50	1 50
Two members are delinquent for assessment account Executive Board of Council of Engineering Societies, National Public Works at $1.00	2 00
Total Dues Uncollected	$ 232 00
Balance in Treasury	69 50
Assets	$ 301 50
Liabilities—Bills outstanding, but not presented, about	90 00
Net Assets	$ 211 50

There are now upon the Roll of Membership fifty-six active and two associate members; seven members having been added to the Roll and one active member made an associate since my report of January 19th, 1889.

During the year we have been called upon to mourn our first loss by death—General B. H. Greene, President of the Society.

During the year eleven regular and four special meetings have been held at which the following papers were read:

"The Panama Canal," addressed by retiring President Geo. K. Reeder.
"County Records," by Geo. O. Foss.
"Manner of Conducting Public Land Surveys in Montana," by R. J. Walker.
"Construction of Modern Fire Proof Buildings," by L. O. Danse.
"Ancient Roman Masonry," by J. T. Dodge.

The paper by Mr. Foss upon "County Records" was the father of a bill—prepared by a Committee of the Society—and entitled a "Bill relating to Town and Village sites and plats" which was presented to the Legislature and with a few modifications made by that body, became a law. This was the Society's maiden effort toward framing legislation and through this success we should feel much encouraged in further efforts toward advising legislation affecting engineering subjects.

A letter from Mr. Geo. H. Robinson suggested another bill designed to improve the law affecting mineral location, which was prepared by a Committee of the Society and presented to the Legislature and only failed through a tie vote in the Council, after having passed the House, practically by a unanimous vote.

The paper by Mr. Walker relative to the "Manner of Conducting Public Land Surveys in Montana," suggested a Committee on that subject. A letter has been addressed and forwarded to the Honorable Thos. H. Carter, M. C., relative to the present objectionable manner of conducting public land surveys and suggesting remedies. This letter is now being printed in the JOURNAL OF THE ASSOCIATION OF ENGINEERING SOCIETIES and 100 copies have been ordered in pamphlet form.

While we have not demonstrated that we are ambitious in the matter of writing papers, our records show that we have been active in other channels, in which I believe in this country, our efforts will be found as better directed than in undertaking to produce too many abstruse papers. There is a gradually increasing interest being shown in the Society by the members and our Society while young, is now being fully recognized in our own section and is taking rank with kindred societies throughout the country.

The records show the existence of the following Committees:

Committee on Topics—J. H. Ellison, Chairman.
" " Highway Bridges, Geo. O. Foss, Chairman.
" " National Public Works, B. H. Greene, Chairman.
" " Transfer of members, A. E. Cumming, Chairman.
" " Public Land Surveys, W. W. DeLacy, Chairman.
" " Library, G. K. Reeder, Chairman.
" " Boiler Inspection, F. L. Sizer, Chairman.
" " Irrigation in Montana, W. W. DeLacy, Chairman.
" " Affiliation with Am. Soc. C. E., W. A. Haven, Chairman.
" " Membership, Walter S. Kelly, Chairman.
" " Memorial of General B. H. Greene, J. S. Keerl, Chairman.

A majority of the Committees have made no report, but it is hoped they have reserved them for this Annual Meeting.

As Librarian of your Society, I can but regret having so little to report. While our Constitution provides, as one of the means to the attainment of its object, viz.: "The collection of a Library" it would appear that such an accomplishment was to be deferred to some day in the far distant future.

A Committee was appointed during the first half of the year and authorized to expend $10.00 for books for the Library. Whether or not their want of compliance with this direction was due to their fear of depleting the Treasury, I cannot say, but the fact remains that no books have been secured from this source.

During the year the back volumes of the JOURNAL OF THE ASSOCIATION OF ENGINEERING SOCIETIES (ordered in 1888) were added to the Library—with the exception of Vol. 1 which could not be secured.

Mr. Kelly has contributed the *R. R. Gazette* for the years 1887 and 1888. General Greene contributed the transactions of the American Society of Civil Engineers for the years 1884 and 1887.

Mr. Danse has presented some of the proceedings of the Engineers' Society of Western Penna. and other miscellaneous papers.

In addition to a few minor pamphlets from manufacturing firms, catalogues, etc., we have received the reports of the State Engineer of Colorado from 1883 to 1888 inclusive. I have the honor to be,

Your obedient servant,

J. S. KEERL, Secretary and Librarian.

Mr. Charles W. Hemlick, Treasurer, read his report for the year ending January 18th, 1890. These reports together with Account Books of the Secretary, were referred to the Board of Trustees for audit and recommendations as provided by the By-laws.

Messrs. Hemlick and Wade were appointed Tellers to count the ballots received for officers for the ensuing year and reported the following as elected:

President, Elbridge E. Beckler; First Vice-President, John Gillie; Second Vice-President, John Herron; Secretary and Librarian, Charles B. Griffith; Treasurer, Albert S. Hovey; Trustee for three years, Adelbert E. Cumming.

The President-elect made a pleasant speech, appreciative of the honor conferred, and promising to lend both effort and influence in promoting the best interests of the Society and asking the hearty co-operation of the individual members.

Mr. Keerl, the retiring Secretary and Librarian, spoke of what had been done by the Society, and called special attention to the fact that all the good work of a Society of this character is not necessarily accomplished through preparing abstruse papers on engineering subjects, for there was a great field open to it in influencing legislation with the view of shaping and securing proper direction of both private and public improvement of an engineering character; that the existence of a Society of this character would appear to signify the acceptance of certain responsibilities to the State and in conclusion hoped the Montana Society would not be found wanting in their full discharge.

A vote of thanks was tendered Mr. Beckler, the retiring First Vice-President, for the interest taken in the Society and for the use of his office as a meeting place.

It was the unanimous sense of the meeting that the Society is under many obligations to Mr. J. S. Keerl, its retiring Secretary, for the able and careful manner in which he has discharged the duties of his office since the organization of the Society and it sees him retire with much regret.

A letter was read from Honorable Thomas H. Carter acknowledging receipt of the Society's letter and promising to consult with the Interior Department with a view to the preparation of a bill for presentation to Congress looking to improving the methods of making Public Land Surveys.

Letters were read from members of the Society, expressing deep regret over the great loss the Society sustains in the death of its late President General B. H. Greene.

Mr. Keerl introduced the following amendment to the By-laws: That Section 6 of Article 4, be amended to read as follows:

"The annual dues shall be $8.00 for non-resident and $10.00 for resident members of Helena, and shall be paid to the Secretary on or before the first regular meeting in July of each year."

Ordered printed and sent to each member for his vote.

After some discussion on the re-appointment of standing committees, on motion of Mr. Pearis, the Chair appointed the following Committee on Standing Committees to report at the next regular meeting: Messrs. Pearis, Wade and Keerl.

Adjourned. C. F. PEARIS, Acting Secretary.

ENGINEERS' CLUB OF ST. LOUIS.

32[illegible]TH MEETING, JANUARY 22, 1890.—The club met at 8:10 p. m. in the rooms of the Elks' Club, President Nipher in the chair, thirty-three members and eight visitors present. The minutes of the 316th and 317th meetings were read and approved as corrected. The executive committee reported the doings of its 81st and 82d meetings, establishing the dues for 1890 and approving the applications for membership of B. J. Arnold and James Dun. They were balloted for and elected. Applications for membership were announced from the following parties: J. I. Ayres, O. W. Connett, B. L. Crosby, J. H. Curtis, G. H. French and A. Winslow. These were referred to the executive committee.

Col. Meier, chairman of the committee on Eads monument, reported progress. The committee had taken the matter actively in hand, and had every reason to believe the project was feasible. The committee found the scope of its duties widening and asked for further powers, which, on motion, were granted, with authority to add to their number such citizens, not members of the club, as they might select, with a view of furthering the objects of the committee.

On motion it was ordered that a vote of thanks be extended to Mr. T. C. Mendenhall, superintendent of the United States Coast Survey, for the address delivered to the club on the evening of January 17th.

Prof. W. B. Potter then addressed the club on the subject of "Fuel Gas." He considered the subject under the heads of natural and manufactured gas. The con-

ditions necessary for the development of natural gas were stated, as well as the reasons for believing that the outlook was not favorable for finding gas in this vicinity, giving the results of some efforts in that direction. The amount of natural gas now being consumed is equivalent to about 17,000,000 tons of coal annually. Manufactured gas was considered under four heads: Retort or coal gas, producer gas, water gas and mixed gas. Drawings of gas apparatus were shown, together with a number of improved designs. An interesting table was presented of analysis of the various kinds of gases, comparing their characteristic features. The cost of evaporating 1,000 pounds of water with each kind of gas was given. The professor was of the opinion that fuel gas could not at present be profitably used under steam boilers. The advantages of gas for this purpose, however, were well known, and he had reason to believe that good results might be obtained by constructing producers in direct connection with the boilers, not attempting any general distribution of the gas. More information on this subject was promised for a later date. The outlook for cheap fuel gas of the mixed type for domestic use was not considered promising on account of the great capital required for installment of plant to distribute gas of such comparatively low calorific value and the risk of future legislation against gas containing so large a proportion of carbonic oxide. There seemed to the author of the paper but little doubt, however, that the "retort," or coal gas, as at present manufactured, would be reduced in price and largely used for domestic purposes. The high calorific value of this gas and the great improvements made recently in the means of applying it in domestic operations were considered sufficient reasons for considering development in this direction as promising.

Mr. Emerson McMillan, president of the American Gas Light Association and of the Laclede Gas Light Company of this city being present, was called upon. He stated that the fuel gas question was to him a sort of a hobby. He gave a statement of his experience elsewhere. In his opinion, it was by no means certain that natural gas could not be found in this vicinity, although the condition appeared unfavorable. Natural gas has sometimes been found where all the indications were against it. He endorsed all that Prof. Potter had said, and was glad to see the results put in such clear shape. He expressed his intention of endeavoring to solve the fuel gas question in St. Louis in the near future, by making and distributing it from an existing plant in this city, and if the people supported the enterprise it would be continued and extended. Replying to the question as to the relative cost of manufacture and distribution, Mr. McMillan stated that in an extreme case which had come under his observation the distribution cost four times as much as the original cost of the gas. In well designed and equipped works, these items of expense should be about equal. The European practice was to estimate that one-third of the selling price of gas should pay the interest on the investment, one-third the cost of manufacture and one-third the cost of distribution. He called particular attention to the fact that mains used for distributing fuel gas could be used for probably fifteen hours of twenty-four, while those used for illuminating gas were used probably three hours. The fixed charges, therefore, per 1,000 feet of gas delivered would be greatly reduced.

The discussion was participated in by Messrs. Ed. Flad, Wheeler, Russell, Robert Moore, Col. Meier, Prof. Gale and Prof. Johnson. It was stated that it was difficult with ordinary fuel gases to give them a permanent odor, which would enable small leakages to be promptly detected. It was also shown that the capacity of steam boilers using fuel gas was almost doubled on account of better distribution of the heat. The gas fields at Sparta and Litchfield, Ill., being referred to, Prof. Potter stated that they were merely local and of no great quantity, and gave further reasons for his opinion against the probability of finding natural gas in this vicinity in quantities large enough for industrial purposes. Adjourned.

Wm. H. Bryan, Secretary.

ENGINEERS' CLUB OF KANSAS CITY.

January 6, 1890.—A Regular meeting was held in the club room at 8 p.m. President O. B. Gunn in the chair; Kenneth Allen, Secretary. There were present nine members.

Minutes of the last regular meeting and those of the meeting of the executive committee were read and approved.

The Treasurer reported as follows for the period of December 5th, 1888, to date:

REPORT OF THE TREASURER.

TO THE OFFICERS AND MEMBERS OF THE ENGINEERS' CLUB OF KANSAS CITY.—Gentlemen: Your Treasurer would respectfully submit the following report covering the interval from Dec. 5th, 1888, to Jan. 6th, 1890.

Our sources of revenue have been as follows:

Amount in hands of former Treasurer Dec. 5th, 1888	$ 94.02
Amount due from members Dec. 5th, 1888	135.00
Initiation fees from Dec. 5th, 1888, to date	115.50
Annual dues for 1889	648.00
Sale of tickets for annual dinner Jan. 28th, 1889	140.00
Rent of club room to Architects' Association from Oct. 1st to Dec. 31st, 1889	25.00
Total	1,157.52
There have been received from the above sources	$ 903.52
The dues of Messrs. Chanute, Nelles and F. Allen remitted	24.00
The dues of five members dropped, aggregating	103.00
The amount now due from fourteen members is	127.00
Total	1,157.52

The following disbursements have been ordered and made:

Journal of the Association of Engineering Societies	$ 146.50
Periodicals	40.30
Rent of club room, including gas	116.00
Furniture and fixtures for club room	91.33
Printing, stationery, postage, etc	160.92
Salary of Secretary	75.00
Annual dinner Jan. 28th, 1889	219.00
Total	849.07
Total receipts	$ 903.52
Total disbursements	847.07
Balance on hand	56.45
Amount due from members	127.00
Estimated liabilities	220.00
Estimated deficit	36.55

Respectfully submitted,

F. W. TUTTLE, Secretary.

On canvas of ballots the following were elected officers for the coming year: President, W. H. Breithaupt; 1st Vice-President, J. A. L. Waddell; 2d Vice-President, A. J. Mason; Directors, Wm. B. Knight, W. Kiersted; Secretary, K. Allen, Treasurer, F. W. Tuttle; Librarian, C. E. Taylor.

The President elect then took the chair.

The retiring President delivered an address pointing out in brief the prosperous condition of the Club, the work being done by various members, and mentioning several of the great Engineering enterprises now being carried out.

On motion of O. B. Gunn it was voted that the Executive Committee obtain the sentiment of the members with regard to changing the date of meeting.

On motion of W. Kiersted it was voted to hold an informal lunch after the next meeting at the expense of the Club, and to invite at that meeting the views of different members as to the advisability of having several such lunches during the year in place of the banquet as heretofore.

Adjourned.

Members desiring special books on engineering subjects added to the Club library are requested to hand the titles of such books to the executive committee, which will, when funds are available, use its discretion in purchasing them.

From the fact that the first Monday of the month is usually a busy day among

engineers in general, and particularly so for the city engineer, and from the fact that the annual meeting comes but two days after a regular meeting, it has been proposed to change these dates, as provided in the By-Laws, and members are invited to notify the Secretary of such dates as they may prefer.

If not correct on the envelope please send corrected address at once to the Secretary for insertion in a new list of members.

Mr. Wm. B. Knight has been appointed by the executive committee to continue as representative on the Board of Managers of the Association of Engineering Societies for the current year.

Mr. W. H. Breithaupt, having resigned from the Committees on National Public Works and Affiliation of Engineering Societies, Messrs. O. B. Gunn and W. B. Knight have been appointed to serve on the former and Messrs. W. Kiersted and Henry Goldmark on the latter. KENNETH ALLEN, Scretary.

CIVIL ENGINEERS' CLUB OF CLEVELAND.

JANUARY 14, 1890.—The regular monthly meeting was held in Case Library, and was called to order at 8 P. M.

In the absence of the President and Vice President, Mr. A. H. Porter was called to the Chair.

The minutes of the preceding regular meeting of December 10, were read and approved.

Messrs. Sidney H. Short, Fred. E. Bright and L. E. Holden were elected to active membership.

A communication from the Executive Board was read recommending that Jas. Chas. Wallace and Arendt Anstrom be admitted active members of the Club.

The Secretary read a communication from Prof. L. M. Haupt, offering three prizes, $300, $200 and $100 for the three best papers on road making and maintenance. He also read a letter from the President, saying that as Section 5 of the By-Laws states that "At the regular meeting in January, the President shall appoint two committees on nomination," he would appoint:

Messrs. M. E. Rawson, S. T. Wellman, John L. Culley, and John Whitelaw, J. N. Richardson, Chas. E. Strong.

Mr. W. H. Searles then stated "The Journal of the Association after the current month, will be printed in Chicago and Mr. Weston of Chicago has been elected Secretary, who will perform the duties of Secretary to the Association in a general way, as well as edit the Journal. The Journal of the Association will not in any way be connected with the American Journal in Chicago. It will be a distinct issue as it has heretofore been issued.

Mr. A. Mordecai presented a paper on "The Harbor Facilities of Cleveland, especially for handling Coal and Ore," which he compared with other competing ports on the Lake. He then introduced Mr. Edward Lindsley who exhibited a model of a machine for unloading coal cars by inverting them and thus avoid as much as possible the breakage of coal.

This was followed by a paper by Mr. J. H. Sargent, entitled "A Belt Line Railway and the improvements of the Lake Front"; after which, the meeting adjourned.

C. O. PALMER, Secretary.

BOSTON SOCIETY OF CIVIL ENGINEERS.

JANUARY 15, 1890.—A regular meeting was held at the American House, Hanover street, Boston, at 19:45 o'clock. President FitzGerald in the chair. Thirty-two members and eight visitors present.

The record of the last meeting was read and approved.

Messrs Lewis M. Bancroft and George N. Fernald were elected members of the Society.

The following were proposed for membership: Frederick W. Farnham, Willard M. Foster and Alfred E. Nichols, all of Lowell, Mass., recommended by G. E.

Evans and W. A. Favor; and F. S. Pearson of Boston, recommended by C. D. Bray and C. S. Parsons.

The Secretary read a communication from the proprietors of the American House in relation to providing rooms for the meetings of the Society and for the library. On motion of Mr. Rice, the Librarian was authorized to move the library to the American House, and the Government to dispose of such of the furniture of Society as it deems advisable.

The President reported for the Government in relation to employing a stenographer, and on motion of Mr. Smith it was voted: That the Board of Government employ a stenographer at such times as may seem desirable.

On motion of Prof. Allen the new constitution and by-laws, adopted at the last meeting, was ratified by a vote of twenty-five in the affirmative and none in the negative.

On motion of Mr. Folsom the chair was requested to appoint a committee of three to select a committee of five to nominate officers. The chair appointed as the committee Messrs. Folsom, Swain and Parsons.

Later in the meeting, this committee reported as the committee to nominate officers under by-law 5, the following members and they were unanimously chosen: L. F. Rice, C. H. Swan, C. F. Allen, E. W. Howe and G. T. Sampson.

On motion of Mr. Hodgdon, the same committee was requested to report at the next meeting a candidate for Vice-President and a candidate for Director, to be elected at that meeting, whose terms of office shall expire at the annual meeting in 1891.

On motion of the Secretary it was voted to hold the annual dinner on the second Wednesday of March, and on motion of Mr. Rice the Secretary and the Treasurer were appointed a committee to make the arrangements for the dinner.

The President then introduced Prof. Thomas M. Drown of the Institute of Technology, who read a very interesting paper on "Filtration of Natural Waters". The paper was discused by Dr. S. W. Abbott of the State Board of Health and by Messrs. Fitzgerald, Smith and Watson of the Society.

Adjourned.

S. E. Tinkham, Secretary.

ASSOCIATION OF ENGINEERING SOCIETIES.

ORGANIZED 1881.

Vol. IX. March, 1890. No. 3.

This Association, as a body, is not responsible for the subject matter of any Society, or for statements or opinions of any of its members.

THE CHICAGO DRAINAGE PROBLEM—THE OVERFLOWS OF THE DESPLAINES RIVER.

By Ossian Guthrie, Member Western Society of Engineers.

[Read September 4, 1889.]

An emergency seems to have arisen in the discussion of some features of the Chicago drainage question which calls for information which my long experience has placed in my possession.

For over forty-two years the opportunity has obtruded upon, and personal interest has compelled me to observe the characteristics of the Desplaines river and Lake Michigan. For twenty years of this time my official responsibilities and cares were in an inverse ratio to the flow of the Desplaines; hence, this particular feature is offered in the confident belief that it will receive due credit.

My first lesson in lake fluctuations was forced upon me in October, 1846, by a sudden rise in the river at Bridgeport flooding a number of barrels of cement which I had placed along the bank to support runways from a scow loaded with that commodity. Those solid and unimpeachable witnesses lingered many years as evidence of my inexperience.

In considering the Chicago Drainage Problem almost the first questions which confront the engineer at this time are, to what extent and in what manner does the flood volume of the Desplaines river affect her drainage and water supply? What other relation does it bear to the proposed waterway and drainage channel, either in construction or capacity? A description of the drainage basin of that river above Lemont, and data concerning precipitation and its known effects, will enable us to consider these questions intelligently. To these features of the problem, therefore, I will first call your attention.

The Desplaines river rises a few miles west of Kenosha, in the State of Wisconsin, and runs nearly parallel with the shore of Lake Michigan, passing through Riverside ten miles west of Chicago.

At Riverside its course is interrupted by a rock barrier; and between

Riverside and Summit, a distance of about two miles, in a direct line, its course is very tortuous and the character of its valley, as well as its course, changes.

For a distance of about one mile above Summit the bed of the river occupies what perhaps may be properly termed neutral ground. This neutral ground comprises nearly the whole of Section 12 in Lyons Township, its average elevation being about ten feet above Chicago datum. The Ogden-Wentworth dam is located in the northeast quarter of this section, and within its boundaries the water-worn channel of the upper Desplaines terminates.

Here the course of the river changes to the southwest, and the valley through which it henceforth flows, bears no resemblance whatever to the valley above. In the southeast quarter of Section 11, same township, the channel crosses a ford composed of glacial debris, which has an elevation almost exactly the same level as the channel bed at Lemont. The channel between Summit and Lemont (the twelve-mile level) has a basin area of fifty-six square miles, and is a succession of long, deep, and wide pools connected by shallow and crooked fords. All the fords, like the one at the head of the level, are composed of glacial debris, and generally change the course of the stream. Flag Creek, its principal tributary, has a bed declivity of about seven feet to the mile, and the entire water shed of the level is nearly as steep. Both banks of the river above the Sag are above fifty feet in height, precludiug the possibility of overflow except toward Chicago.

On the occasion of an incipient flood in February, 1882, which lasted only a few hours, I saw this level rise five feet in about four hours. The conditions of this flood were similar in every respect, except duration, to the flood of February, 1887, which caused so much alarm. During that flood the capacity of the channel through this level, at that stage, was demonstrated to be less than 5,000 cubic feet per second, only that amount passing over the Adams dam at Joliet, while 8,000 cubic feet passed through Mud Lake.

By reason of the almost impermeable character of the soil, the steep slopes of the whole watershed and the steep bed declivity of the upper river, the rainfall is so precipitated into its flood discharge as to leave barely enough flow to maintain the integrity of the stream in dry weather. The valley between Summit and Lemont varies from a width of ½ mile to a mile and a half, and was made for a grander purpose than providing for the fitful flow of the upper Desplaines. At the beginning of the last glacial epoch, or possibly that of its predecessor, what is now locally known as the Chicago divide was selected by Nature, and, as we are constrained to believe, upon sound engineering principles, as the most fitting line for the passage of one of the most stupendous glaciers of His creation, that which came down Lake Michigan; and through this the weakest point in the great continental divide, the glacier forced a passage, cutting a continuous channel in the rock to Lemont, and, as is now believed, to a depth of over fifty feet, certainly deep enough for the proposed waterway and drainage channel. Thenceforth to the close of the glacial epoch this channel, together with its only coadjutor, the "Sag" extending from the Calumet river to the

Desplaines, provided not only for the passage of the ice, but also for the flood torrents from the retreating glacier; compared to which, at times, the present outflow from Lake Huron would be dwarfed. Its grand purpose being accomplished and its bed filled to its present level by debris from the retreating glacier, Nature planted the seeds of the future forest and field, and these in time grew to obstruct and minimize the capacity of the flood channel of the present Desplaines, as above described.

The wide and deep pools of the lower river and the ponds of the upper are prolific producers of ice, ice often forming over their surface to a depth of twenty to twenty-four inches. In many places within the flood line of the lower valley a heavy growth of timber is still standing, in others stumps of fallen timber still remain; and the flood volume, through this stretch, crosses the channel proper, several times, at angles varying from 30 degress to a right angle. In short, it would be difficult to find another channel where so many conditions had conspired to minimize its capacity.

It has already been stated that the valleys of the upper and lower river bear no resemblance to each other. The difference and the causes producing it will, we believe, be made obvious as we proceed.

The channel of the Upper Desplaines is a characteristic water-worn channel. At the close of the last glacial epoch this stream, doubtless, flowed into a magnificent bay, nearly circular in form and about twenty miles in diameter, extending from its rocky rim on the west to Lake Michigan, to which it formed a terminal appendage not unlike that of the cornucopia, which symbol (with a slight stretch of imagination) at that period it somewhat resembled. In support of this suggestion I will quote Dr. Edmond Andrews of this city. In a paper read before the Chicago Academy of Sciences in 1870 he gave the average annual erosion between Milwaukee and Evanston as 6.24 feet and north of that point, Milwaukee to Manitowoc, 4.33. Now, from the best geological authority of the period 7,500 years, more or less, have elapsed since the glacial epoch. This, according to Dr. Andrews' estimate of erosion, would establish the original shore of the lake about nine miles from the present shore line. Thus, forming a bay bounded on the south by Thornton and Bloom, on the west by Palos and Lyons, Blue Island and Lanes Island, were islands in fact as well as in name.

It has already been stated that the Upper Desplaines discharged into the bay above described. During the period of subsidence, the Desplaines followed the retreating bay to Lake Michigan, expanding meantime over the bed of the now extinct bay, which thenceforward to the time of man's interference, furnished a quiet resting place for the silt from the upper river. The location of the future sedimentary dam was determined by natural causes and its construction begun, while yet the bay was retreating. Sedimentation and vegetation had contested with the Desplaines floods for the mastery, for more than seven thousand years, and but for the interference of man, would have eventually forced its flood waters through the glacial valley below, and into which the normal flow had long since been diverted. This dam, or divide, was cut through by the Cook County Drainage Commission about 1850.

The ditch, originally only about three feet wide and two deep, was

rapidly enlarged to navigable proportions by the concentrated force of the overflow from the Desplaines. This post glacial divide crossed Mud Lake valley about where Kedzie Avenue is now located. Another, but inferior divide was formed adjacent to and parallel with the normal current of the Desplaines, in its passage from the upper to the lower valley. This divide has attained an elevation of about eleven feet above Chicago datum, or three feet above the surface of the Desplaines at low stage. After the destruction of the Kedzie Avenue divide was accomplished, this inefficient barrier was all the protection Chicago had against overflow from this river. In 1871 the Ogden-Wentworth ditch was permitted, by the city authorities, to be cut through this only barrier, after repeated warnings; and this, while yet the finishing touches were being put upon the $3,000,000 job, the deepening of the Illinois and Michigan canal.

It has already been shown that the drainage basin of the Upper Desplaines contained 634 square miles, had steep slopes and an impermeable soil. That the twelve-mile level had no bed declivity whatever, that it had a basin area of fifty-six square miles with very steep slopes, impermeable soil and the flood channel obstructed by natural causes to a flow as shown in the flood of February, 1887, of less than 5,000 cubic feet per second, while 8,000 passed through the gap in the Kedzie Avenue divide.

"FLOOD OF 1849."

Prior to the memorable "flood of '49," it probably may be said without qualification, that not one mile of graded roadway or open drain existed in the drainage basin of the Desplaines river north of Lemont, neither had a single length of tile drain been laid. Everything was in a state of nature in this respect, consequently much of the water then stored in this basin never reached the river, and what did, was materially retarded in so doing. Then there were no artificial obstructions to impede the flow of the lower river and the divides were unimpaired.

The winter of 1848 and '49 was inaugurated November 27th, without snow or rain, the winter thereafter being severe and the snowfall heavy. The spring was inaugurated by the "flood of March 12, 1849," for the following description of which I am indebted to Andreas' History of Chicago.

The Flood of 1849.—The flood which occurred March 12, 1849, was an event of most calamitous nature. For two or three days previous to that date the citizens of Chicago had been reading accounts of the remarkable rise of rivers in the interior of the State. The heavy snows of the winter had been followed by frequent and hard rains. Rock, Illinois and Fox rivers were threatening to burst their bounds and devastate the country. Their waters were higher than in 1838, and, in some localities, even than in 1833. The bridges on Rock river were nearly all swept away, and the Illinois had partially destroyed the village of Peru. The Desplaines river was also higher than it had ever been before. The following account of the flood, from the pen of Rufus Blanchard, is taken verbatim:

"The last thing one might expect in Chicago, situated as it is on almost a dead level, is a flood, in one of the branches of its river. But this actually took place one fine morning in March, 1849. After two or three day's heavy rain, which had been preceded by hard snow storms during the

latter part of the winter, the citizens were aroused from their slumbers by reports that the ice in the Desplaines river had broken up; that its channel had become gorged with it; that this had so dammed up its waters as to turn them into Mud Lake, that, in turn, they were flowing thence into the natural estuary, which then connected the sources of the South Branch of the Chicago river with the Desplaines. These reports proved to be correct. Further, it was also rumored that the pressure of the waters was now breaking up the ice in the South Branch and branches; that the Branch was becoming gorged in the main channel at various points, and that if something were not done, the shipping which had been tied up for the winter along the wharves would be seriously damaged. Of course each owner or person in charge at once sought the safety of his vessel, added additional moorings to those already in use, while all waited with anxiety and trepidation the result of the totally unexpected catastrophe. It was not long in coming. The river soon began to swell, the waters lifting the ice to within two or three feet of the surface of the wharves; between nine and ten A. M. loud reports as of distant artillery were heard towards the southern extremity of the town, indicating that the ice was breaking up. Soon, to these were added the sounds proceeding from crashing timbers, from hawsers tearing away the piles around which they were vainly fastened, or snapping like so much pack-thread, on account of the strain upon them. To these in turn were succeeded the cries of people calling to the parties in charge of the vessels and canal boats to escape ere it would be too late; while nearly all the males, and hundreds of the female population, hurried from their homes to the banks of the river to witness what was by this time considered to be inevitable, namely, a catastrophe such as the city never before sustained. It was not long before every vessel and canal boat in the South Branch, except a few which had been secured in one or two little creeks, which then connected with the main channel, was swept with resistless force towards the lake. As fast as the channel at one spot became crowded with ice and vessels intermingled, the whole mass would dam up the water, which, rising in the rear of the obstruction, would propel vessels and ice forward with the force of an enormous catapult. Every lightly-constructed vessel would at once be crushed as if it were an egg-shell; canal boats disappeared from sight under the gorge of ships and ice, and came into view below it in small pieces strewing the surface of the boiling water.

"At length a number of vessels were violently precipitated against Randolph street bridge, then a comparatively frail structure, and which was torn from its place in a few seconds, forcing its way into the main channel of the river. The gorge of natural and artificial materials—of ice and wood and iron—kept on its resistless way to the principal and last remaining bridge in the city, on Clark street. This structure had been constructed on piles, and it was supposed would prevent the vessels already caught up by the ice from being swept out into the lake. But the momentum already attained by the great mass of ice, which had even lifted some of the vessels bodily out of the water, was too great for any ordinary structure of wood, or even stone or iron to resist, and the moment this accumulated material struck the bridge it was

swept to utter destruction, and with a crash, the noise of which could be heard all over the then city, while ice below it broke up with reports as if from a whole park of artillery. The scene just below the bridge, after the material composing the gorge had swept by the place just occupied by the structure, was something that bordered on the terrific. At State street, where the river bends, the mass of material was again brought to a stand, the ice below resisting the accumulated pressure, and the large number of vessels in the ruck, most of which were of the best class, the poorer ones having previously been utterly destroyed, helping to hold the whole together. In the meantime several canal boats, and in one instance a schooner with rigging all standing, were swept under this instantaneously constructed bridge, coming out on the eastern side thereof in shapeless masses of wreck."

The river bed beneath the gorge was scoured out to a depth of forty feet.

The following additional particulars are gathered from the files of the Chicago *Evening Journal:*

"At about ten o'clock the mass of ice in the South Branch gave way, carrying with it the bridges at Madison, Randolph, and Wells streets—in fact, sweeping off every bridge over the Chicago river, and also many of the wharves. There were, in port, four steamers, six propellers, twenty-four brigs, two sloops, and fifty-seven canal boats, many of which have been either totally destroyed or damaged seriously. The moving mass of ice, canal boats, propellers, and vessels was stopped at the foot of Clark street, but withstood the pressure only a moment, crashing vessels and falling spars soon giving note of the ruin which was to follow. A short distance below the river was again choked, opposite Kinzie's warehouse; vessels, propellers and steamers were piled together in most indescribable confusion. A number of vessels are total wrecks, and were carried out into the lake a mass of debris. A boy was crushed to death at the Randolph-street bridge, a little girl was killed by the falling of a top-mast, and a number of men are reported lost upon canal boats which have been sunk, and upon the ice and bridges as the jam broke up. The bridge over the lock at Bridgeport is gone. The wharves all along the river have sustained serious injury. A son of Mr. Coombs was lost at Madison-street bridge, and James L. Millard had his leg badly fractured while on board his vessel."

After the flood had begun to subside, I purchased 12x12 pine timber for a pontoon bridge, to replace the bridge at the lock. This timber was hauled out on the prairie to about the point where 12th street now crosses Blue Island avenue, and from there it was rafted across the prairie to Bridgeport.

TO THE COMMITTEE ON MAIN DRAINAGE AND WATER SUPPLY CITIZEN'S ASSOCIATION.

Gentlemen:—At the time of the great flood in March, 1849, the late William B. Ogden and John B. Turner, in order that they might determine how so large an amount of water came so suddenly upon us, took a yawl from the Chicago river across the prairie west, on the line of Kinzie

street, to the Desplaines river; going from that point down the river to its junction with the Mud Lake channel, thence through Mud Lake to the Chicago river. Between the two rivers they found a large body of water extending from the high embankment on the northerly bank of the canal, north, more than a mile in width, and easterly several miles until it fell into the South Branch of the Chicago river. The current from the Desplaines, which was marked, set through the bed of Mud Lake, following the course of the channel through which, always in a flood, the waters of the Desplaines flow to Lake Michigan through the South Branch of the Chicago river.

Those gentlemen frequently measured the depth of water in passing between the two rivers, and at no point did they find less than nine feet, and in many places could not touch bottom with their sounding poles. They gave it as their opinion at the time, that any vessel navigating the lakes could easily have passed from the South Branch over the prairie to the Desplaines river. The water flowed with a fierce current even with the top of the wharfs or docks, and swept away every bridge on the South Branch and main river. Nearly every vessel was torn from its moorings, and canal boats and schooners when they reached the gorge at the foot of Wabash Avenue, collapsed and disappeared.

This statement is made at the request of a member of your Committee.

Yours respectfully,

EDWIN H. SHELDON.

The Desplaines overflowed the protection bank of the canal from Sag to Bridgeport, and from Summit to Bridgeport, flowed entirely across the canal until a break occurred in the berm bank sufficient to relieve it. This break was so large that a loaded canal boat passed safely through it and into the "South Fork," the river of course being then but a few inches lower than the canal.

From the foregoing it will be seen that the memorable "flood of 49," so graphically described in the quotations above, was caused by the accumulated precipitation of 105 days, (the above dates are established), being precipitated by natural and seasonable causes, into a flood of a few days duration, causes which common prudence would seem to lead us to anticipate, and guard against.

Since the "flood of 49" several incipient floods have occurred which have been checked in their mad career by unseasonable temperature; a number of these might be cited, but I will only describe four, one of which occurred Feb. 9, 1857, and those of 1881, 1887, and July, 1889.

A description of the flood of 1857 will be both interesting and instructive. The winter of 1856–'57, set in about December 1st, was more than ordinarily cold and the snowfall was heavy, but not excessive, and culminated in the flood of February 9th. A warm rain of the preceding day melted the snow rapidly and caused a flood which for a few hours threatened to outrank that of '49. Water spread over the prairie where the West Side Pumping Works now stand, to a depth of two or three feet and drove the residents of the locality into the lofts of their houses during the night and caused great alarm. The ice was thick and its strength was unimpaired, and had the warm weather continued, a disastrous flood must

have resulted; but a sudden freeze checked this in time to avert this calamity, but the people who had sought safety in their lofts spent a night of terrible anxiety and suffering, ice formed over the water thick enough to obstruct the passage of a boat to relieve them and not of sufficient strength to enable them to escape. In the channel of the river anchor ice was running so as to make it very difficult to cross, and it was near noon the next day before they were relieved, a relief party having been organized in the morning and a boat procured for that purpose. Three heroic young men, E. F. Cullerton, Patsey Joyce and James Cullerton, the former for many years since a faithful representative of that district in the council, were the rescuing party. It was a fitting recognition of his ability and a deserved compliment to Mr. Cullerton which the Drainage Committee of the Citizens' Association of 1885 paid him, when that committee entrusted its drainage ordinance to his care in the council; and the almost unanimous vote—26 to 2—by which it was passed showed the committee had chosen wisely.

The overflow of the southwest part of the city since about 1864, when the Panhandle Railroad graded a road-bed across Mud Lake valley has been obstructed, this obstruction has materially modified the effect of overflow east of that grade. This railroad grade just west of Western avenue, is sixteen feet above datum and extends from the canal bank quite across Mud Lake valley, excepting the bridge and pile work at the river. This grade is of ordinary earth work construction and without rip-rap or other protection against water.

Particular attention is called to the location and construction of this grade, for the reason that it is located at the very edge of a large and densely populated district, which, before the grade was made, was subject to frequent overflow from the Desplaines. This grade has sufficient height and only sufficient strength to raise the flood from the Desplaines to a dangerous extent; and as soon as the water is high enough to flow over it its destruction would only be the work of a few minutes. The body of water thus liberated is twenty miles in length, one mile in width, and not less than sixteen feet above lake level, and is brought one mile nearer the city than the original divide. Into this pool, from an elevation of from twenty-four to thirty feet, the rushing torrents from 634 square miles is precipitated. This area in 1849 was in a state of nature; now it is doubtful whether there is an equal area in the State so thoroughly drained as that tributary to the Chicago river in time of flood. The open ditches, (all of which have been cut since 1849,) have been increasing in size in conformity with the increasing demand upon them at flood times, until, in many instances, road ditches threaten the destruction of the road bed. These changed conditions largely prevailed in 1881.

FLOOD OF APRIL, 1881.

The winter of 1880 and 1881 was inaugurated by a snow storm on the 14th of November, and continued *uninterruptedly* until April 1st, when the thaw began, or 21st, when the flood culminated; the latter date making the duration of the winter 158 days, or 53 days longer than that of 1849. During this period the precipitation was below average in the aggregate

.81 of an inch, or about six per cent.; the average aggregate precipitation for the period being 12.81 inches, the actual quantity being 12 inches. The average temperature of the winter was very low. Under these circumstances it is obvious a very heavy body of ice would be formed.

On the 1st of April the ice was about two feet in thickness, and its solidity was unimpaired. These were the conditions which confronted us on the first day of April, 1881.

During this period the average temperature was 34°, the temperature due to the period is fully 10° higher.

The temperature for the corresponding period in 1880 was 59° or 10° higher than that of February 8th, 1887, which produced such a widespread consternation, but the maximum temperature on the 18th was 80° or 31° higher.

The total rainfall during the period was one-half inch, the average due to that period, 2.45 inches and the maximum, now of record, 4.35 inches; but Chicago has become so accustomed to breaking records, that it occasions little surprise to see her take a hand at rainfalls; as for instance, on the 2d of June, 1885, over three inches of rain fell in two hours. From the 1st to 3d of August, that year, 6.25 inches fell in 30 hours, and recently, 27th of July last, the gauge at the Signal Service office, which is fully up to the requirements of such cities as New York and Philadelphia, in slang parlance, "laid down" at 4.12 inches in 3 hours. A member of this Society informed me that over six inches fell in a can in his yard. An open can in my brother's yard at 2822 Indiana avenue, showed 7.25 inches, but as some of this must have been carried over from a preceding rain, it is not offered as reliable. At my house, my kitchen chimney, with an eight-inch flue, stands on a bracket and it became necessary to collect the flow from it. My wife informed me, to my utter surprise, that six quarts of water had thus been collected, showing over five inches of rainfall above what was absorbed by the brick. But recurring to the memorable flood of '81. This flood, under the phenomenal weather conditions above described, caused great alarm for several days, imperiled life and destroyed several thousand dollars worth of property. It caused two breaks in the canal and swept two ice houses and their contents into the canal, besides nearly wrecking several others. Not less than $50,000 damage was done.

It is obvious that frost could not check a flood after the 1st of April, but it might form anchor ice to increase the effect of the gorge.

INCIPIENT FLOOD OF FEBRUARY, 1882.

The winter of 1882 was like that of 1856-7, cold and heavy snow-fall. In February a heavy rain occurred one night, and as before stated the twelve-mile level rose five feet in four hours, when a very sudden change to low temperature took place and checked the flood. The whole occurred almost within twenty-four hours.

FLOODS OF 1885.

In relation to rainfall, and the drainage and water supply questions, the year 1885 will ever remain conspicuous.

On the 2d of June, three inches of rain fell in two hours. Between the

1st and 3d of August 6¼ inches of rain fell in thirty hours, and again in September a heavy rain occurred which caused the overflow of the Desplaines. The effect of these rains upon the water supply of Chicago was very marked. Between the spring breakup and the three rains above referred to, our water supply was contaminated the entire summer, a condition, by many persons, theretofore deemed impossible, but conspicuous among all these causes was the rain of August 2, 1885.

FLOOD OF AUGUST.

This rain afforded an opportunity for settling disputed questions, and concentrating public opinion upon a plan for solving "The Great Drainage Problem." I find in the report of the Drainage Committee of the Citizens' Association of 1885, the following note in relation to the effect of this rain: "On Wednesday, August 5, the river discharge was observed in an unbroken stream to and around the crib," to which I add, a vessel captain informed me that the turbid water reached twenty miles into the lake. By my own observation with the aid of a powerful glass, it was plainly discernible fully half that distance.

This, perhaps, unprecedented rain, occurring as did also that of June 2d, at a high stage of lake, set the water back into the sewer mains and flooded many basements near their outfall. This rain, at the time, was looked upon as a calamity; but to-day it looks as though it was a blessing in disguise.

The rain was, apparently, the dawn of a new era in the consideration of those vital questions—our drainage and water supply. The lessons taught by it have been perpetuated by a united and powerful press co-operating with those individuals who had properly construed its significance and utilized its effect. For this reason the rain of August 2, 1885, should be ever memorable.

FLOOD OF FEBRUARY, 1887.

The flood of February 9th, 1887, when we consider the small quantity of snow accumulated and the rain which fell upon it, only 0.25 of an inch, is most remarkable, almost beyond the conception of those who have carefully studied the characteristics of the Desplaines river; hence your particular attention is called to the following details:

During the month of November, 1886, the total precipitation was 3.25 inches, a little above normal, and this fell under ordinary conditions; hence, we can only assume that the ground was well saturated and that there was nothing more than this in store for the future flood. The winter was inaugurated by a sudden change of temperature on November 28th and culminated in the flood of February 8th and 9th, 73 days, against 158 days of the winter of 1880–81. The precipitation during the time was 2.99 in. or less than one-fourth that of the winter of 1880–81. To the temperature alone then, we must look for an explanation of this phenomenal occurrence, as only one-fourth of an inch of rain fell on the 7th, which was followed by a maximum temperature of 49° on the 8th. Perhaps among the most remarkable occurrences of this flood, was its duration, as witness: On the 7th the maximum temperature was 30° with .25 of an inch of rain,

on the 8th, 49°, rain too light to measure; on the 9th, 27°; thus it will appear, that in duration, from beginning to culmination, it was less than three days. The *Chicago Tribune*, February 9th and 10th, gives very full details of this flood, telling how families had been driven into the lofts of their houses, lumberyards flooded, brickyards and other manufactories seriously injured and threatened with total destruction, etc., entirely too lengthy for this paper. I will therefore only quote its headlines of the 10th, after the excitement had somewhat subsided and when a calm retrospective view could be taken:

"JAMMED ICE AND FLOOD.—*The Lumber District Submerged by an Ice Gorge at Ashland Avenue Bridge—The Fire Boats and a Big Force of Men Trying to Break it.—A Gorge in the Afternoon and How it was Disposed of:*

From 4 o'clock yesterday afternoon until late last night heavy charges of dynamite were exploded to break the gorge, loud reports were heard at intervals and some of them were so loud that they startled people on the West Side," and the water drove the inhabitants into the attics.

Thomas Piper, whose icehouses are at Willow Springs, came into the city and reported that the "Desplaines had overflowed the entire territory between the canal and the high ridge that flanks Riverside. Jack Wilburn's house was about the only object in sight."

FLOOD OF JULY, 1889.

About six o'clock P. M., Saturday, July 27th, a deluge of rain began to fall and continued for about three hours. During this time the rainfall, as recorded at the signal service office, was 4.12, but the gauge overflowed and the actual rainfall may never be accurately known. Elsewhere a more detailed statement has been given. How soon the river began to show the effect of this rain is not accurately known, but the bridgetender at Rush street bridge stated that at 6 A. M., on Sunday, there was a current of six miles per hour. This estimate, without doubt, is too high, as estimates of this character by inexperienced persons, are apt to be. At 2 P. M. the current was observed to be a little more than one mile per hour. A light wind was blowing from a little north of west and the new crib, two and one-half miles from shore, was clearly within the area affected by the outflow, but the water around the old crib had not yet been affected; but during Sunday night the wind changed, and at 7 o'clock on Monday morning the hydrant water was very badly contaminated. On only one of the first five days did the wind blow on shore. On this occasion it was from the northeast and light, but notwithstanding this, the turbid water seemed to be moving northward faster than at any other time since the rain. During these five days the water in the lake was undisturbed, and the foul matter in suspension was allowed to settle over an area extending from Evanston to South Chicago, and not less than five miles in width.

This rain was local, and did not extend in its intensity but a few miles up the Desplaines valley, consequently its effect was immediate and of short duration.

On the ninth day after the rain fell Prof. Long's analysis showed the water to be worse than on any previous day.

FLOODS AND OVERFLOWS.

This general statement may be made, viz: That the Desplaines river overflows the divide in the spring, and during the equinoxial storm in the fall, almost without exception. If my memory serves me, this never failed during the first eleven years after the Bridgeport pumps were started in 1848. During two years of this time, to 1859, the rainfall was so heavy that the Desplaines and Calumet rivers supplied the canal without the aid of the pumps. Here, for the benefit of modern Chicago, it might be well to state, that originally the canal was eight feet above datum, the low lake level of 1847, and these pumps were erected for raising water from the Chicago river when natural sources failed. I will now give the years in which floods and overflows have occurred as near as my memory and the imperfect record will permit. There will be many small overflows omitted without doubt.

May, 1847, before its completion, overflowed the canal and drove the men from their work.

August, 1848, overflowed the protection bank between Summit and Bridgeport, causing the first break. Navigation suspended several days.

March, 1849, causing flood of '49, elsewhere described.

April, 1856, spring freshet.

February 9, 1857, notable, elsewhere described.

August, 1861, no pumping required after that date.

March, 1865, threatening flood.

1871, spring and June.

January, 1874.

April, 1877, broke into the canal near Willow Springs, causing one of the most expensive breaks the canal has ever sustained, and again in October. In October, flooding John Wilburn's cornfield, for which the city paid $495 damages before being allowed to repair Ogden-Wentworth dam, he being the lessee of the land where the dam is located.

1878, spring and July.

1879, spring, July and September. July very heavy; suspended navigation in canal.

1880, spring; May very heavy, and again in June heavy.

1882, February; incipient flood checked by a sudden severe cold wave, mentioned elsewhere. Again in the spring breakups.

1883, from the spring breakup to July 10 the overflow was continuous and neutralized the effect of the canal.

1884, April, Desplaines valley flooded.

1885, spring; June 2, over three inches of rain in two hours. August 1 to 3, over six inches in thirty hours, and again in September.

1887, February, notable, described elsewhere.

1889, July 27, notable, described elsewhere.

From the spring of the year 1880 up to and including the year 1885, the precipitation was considerably above average and the stage of lake was high. The years 1886, 1887 and 1888, and first three months of 1889, the precipitation was unusually light, and as a consequence, the lake reached almost the lowest stage since 1847.

In the foregoing it has been my purpose to confine myself as strictly as

possible to a description of the Desplaines river above Lemont, and a narrative of events connected therewith which have occurred within my knowledge, and to refrain, as far as a truthful narrative would permit, from indicating my own conclusions, or answers to the questions about to be propounded, but I feel constrained to state the following conclusions, viz: That, on an average, under existing conditions, the Desplaines river overflows the divide one month certainly, and possibly two, out of twelve, and that its effect upon our water supply will extend over nearly double that time. That the diversion of the flood waters of the Desplaines river north of Evanston and through the Skokie can be accomplished at a cost not to exceed 25 per cent. of the proposed Bowmanville diversion; and that the enhanced value of the property along that line, which it is assumed will be specially assessed therefor, will materially reduce this estimate so far as the general fund is concerned. These statements or conclusions seem to be demanded as basis for answers to the following questions, viz:

1. Will the diversion of the flood waters of the Desplaines hasten the completion of the main channel in the Desplaines valley?

2. Will the diversion of these flood waters reduce the cost of cutting the main channel in the Desplaines valley? If so, to what probable extent?

3. Will the diversion of these flood waters be of sanitary utility, pending the completion of the drainage channel?

4. Will the diversion of the flood waters of the Desplaines be of sanitary utility after the main channel is completed?

5. What will be the probable cost of diverting the flood waters of the Desplaines across the Skokie, as now proposed?

6. What effect, if any, will the diversion of the flood waters of the Desplaines have on the floods of the Illinois, and the consequent damage for which, under the law, Chicago will be held responsible?

7. The lesson of the flood of '49 teaches us that a flood, disastrous to life and property, can occur from the overflow of the Desplaines river.

The lesson of the flood of February 8th and 9th, 1887, teaches us that when there is a body of ice on the pools and ponds of the Desplaines river and three inches of water in the form of snow has accumulated, a flood of dangerous magnitude may be produced in twenty-four hours by a maximum temperature of 49° and 0.25 of an inch of rainfall. The Signal Service records for 1880 show a temperature on ten of the first twenty-one days of April exceeding 60° and a maximum of 80°. These records also show a rainfall during the same period of 4.35 inches and that the same quantity may fall in three hours.

It has already been shown that twelve inches of water in the form of snow had accumulated on the first day of April, 1881. Question: Should any of these weather conditions occur in conjunction with such an accumulated precipitation as was upon the ground on the first day of April, 1881, would there not be imminent danger to life and property by floods from the Desplaines river?

On Sunday, July 7th, 1879, a rain occurred which extended over the entire basin of the Desplaines river, and to Milwaukee, at which place it was much heavier than at Chicago. This rain made no perceptible change in

the river at Summit until late Monday afternoon, when it began to rise rapidly and culminated in a deluge in the twelve-mile level before daylight on Tuesday morning. This experience demonstrates that the maximum effect of a general rainfall over the Desplaines basin may be precipitated into the twelve-mile level within forty-eight hours. The flood occasioned by the great rain of August 2nd, 1885, had entirely subsided before the 20th of that month, and probably gave a maximum flood volume of 25,000 cubic feet per second. Ordinarily the season would advance from Lemont at the lower end of the twelve-mile level to the source of the Desplaines river in about six days, but it must be borne in mind that it is not a rare occurrence for the temperature at Milwaukee to stand several degrees higher than at Chicago, and should a spring rain occur under such conditions the maximum flood volume might reach 50,000 cubic feet per second, which, should it occur in conjunction with a heavy body of ice, like that of 1881 (about two feet thick) would cost Chicago millions of money and could hardly fail to destroy life.*

Common prudence, as well as justice to the people of the valley, demands that we guard against every possible contingency—cost of specific work can be closely approximated, but the scope of the average jury is boundless. The writer speaks from the standpoint of an unsuccessful defendant at the conclusion of a damage suit of five years duration, in which the jury gave a verdict for the estimated full value of the land, the plaintiff showing it to be totally destroyed and the loss of the crops for two years; and notwithstanding this remarkable verdict of total destruction, the same plaintiff for damage to the same land by the same cause is pressing a claim against our successor through the same attorney for a much larger sum than that which my company paid for the total destruction of the land. With a little delay on the part of the Drainage Trustees, the same plaintiff, with the same land, will probably be ready for a third total destruction.

8. All things considered, is it desirable, or will it be economy, to divert the flood waters of the Desplaines river?

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*The following records of temperature will be of interest in above connection:

			Min.	Max.
Wednesday,	Feb. 12, 1890,	Milwaukee	34°	40°
"	" " "	Chicago	32°	38°
Saturday,	Feb. 15, 1890,	Milwaukee	38°	42°
"	" " "	Chicago	36°	42°
Monday,	Feb. 24, 1890,	Milwaukee	34°	34°
"	" " "	Chicago	34°	34°
"	" " "	Marquette	32°	46°

COMPOUND LUMBER.

By G. A. M. Liljencrantz, Member Western Society of Engineers.

[Read November 6, 1889.]

In presenting this paper to the Society, I desire to preface it with the remark, that, although the subject in hand is of more direct interest to architects and builders, than to civil engineers, it is also a subject of importance to anybody either directly or indirectly interested in the erection of a building or buildings, and I have therefore considered it of sufficient general interest to bring it before this Society.

Among the later enterprises established on the Calumet River is the "Compound Lumber Co's.," Works at Burnham, Ill.

The business of this firm is the manufacture of an article, intended as a substitute, in certain cases, for solid hardwood and for veneering.

It is well-known that certain kinds of hardwood, such as black walnut for example, are gradually growing more scarce and accordingly more expensive. The use of veneering, to obtain a handsome surface with a moderate use of the expensive kinds of hardwood, is very old, but has some serious objections. The thin facings of the hardwood being glued on to flat surfaces, frequently peel off when subjected to any considerable changes of temperature, and the work being always done by hand makes it rather expensive. Shrinkage of the wood used as core, will undoubtedly also cause trouble. Repairs of such damages are apt to be both expensive and unsatisfactory.

"Compound Lumber" is a patented device intended, as already mentioned, to take the place, in certain cases, of hardwood and veneering, having all the good qualities of these; other good qualities not possessed by them and apparently none, or few, of their defects. It is more especially intended for interior house finishing, as for doors, wainscoting, ceiling, etc.

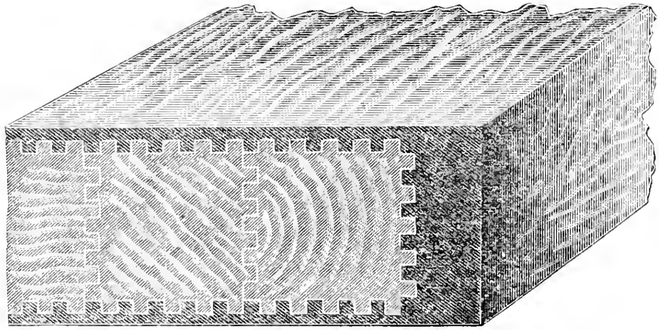
The "Compound Lumber" consists of a core of some soft wood, ordinarily pine, with a facing of some kind or other of hardwood, in varieties to suit different tastes and requirements, and which facing or facings are tenoned and grooved together with the core in a substantial manner.

A large number of different designs are made, some of which are shown by samples exhibited herewith. Thus we have the door stiles, made of a pine core with all four sides covered with hardwood; strips to be used for floors and ceilings and strips with the hardwood made into various different moulds or patterns for wainscoting. The core is some-

times covered on all four sides, as above mentioned, sometimes on two or three, and sometimes again on one side. See engravings.

Besides being tenoned and grooved the adjoining surfaces of the different parts are also glued together between rollers under heavy pressure.

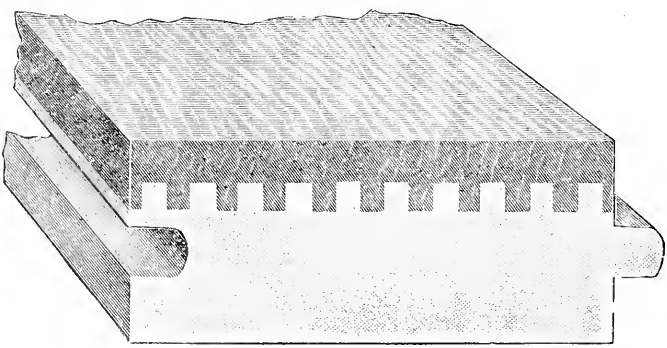
Large cores, as those for door stiles, are made in separate strips, which



are glued and fastened together in the same manner, as additional security against warping. Great care is taken to have all the lumber highly seasoned.

Besides other advantages mentioned the "Compound Lumber" is lighter in handling than solid hard wood, easier to work with, and the core furnishes a better bedding for the nails.

The prices for compound lumber being below the market prices for hard



woods, and having so many other advantages over these, seems to warrant the assertion that this new commodity will, before very long, be generally adopted for all such purposes for which it has been designed.

The process of manufacturing the article is as follows: The lumber is bought in the log and brought to the saw mill, where the logs are first trimmed by a large double "circular" and then placed upon automatic veneer saws set to cut the lumber into the necessary thickness required for facing. As fast as this lumber leaves the saws it is placed on trucks and "rattlings" put between each layer. The number of feet and the date when cut is tacked on, and the trucks run out in position to dry, and

when sufficiently dried by the air they are run into the kilns. Thus the lumber is always handled in bulk until ready for the machine. After remaining in the kilns about a week the lumber is ready for the factory. The success of the work depends largely upon the proper preparation of the lumber.

The drying must be perfect and the best grades of lumber used.

The pine goes through the same process of drying as the hardwood.

Different woods require different treatment, and it requires an expert to regulate this important branch of the work.

Having prepared the lumber, it is brought into the main factory and cut and trimmed by table saws into proper lengths and width, and is next put through machines similar to Sticker machines, having "cutter heads" with knives adjusted to make the grooves. These knives make 4,000 revolutions per minute, making a tenon and groove about ⅛″ deep, with the tenon the smallest possible fraction larger than the groove, insuring a tight joint.

After the lumber is grooved the pine base is put through glue machines with revolving brushes, by which the glue is spread evenly over the grooved surface.

The hardwood top, being first slightly heated, is then placed on the pine and run through large roller presses having a pressure of 5,000 pounds. This is the last operation, which leaves the lumber ready for manufacture into flooring, wainscoting or other interior house finish of various kinds.

The power used is the Wheelock 300 horse-power engine and a 500 horse-power Hazelton Tripod Boiler. All the sawdust and shavings are burned by means of the Allington & Curtis patent exhaust pipes, which keep the entire factory free from this inflammable refuse, feeding it direct to the furnaces.

The present plant covers a little over five acres of ground, on which are at present erected eight buildings. The land has a river frontage of 900 feet, half of which is docked, and it is expected to bring all raw material by water as soon as the Calumet River has been improved up to this point.

In closing, I desire to express my indebtedness to Mr. W. E. Kirkpatrick, the Secretary of the Company, for kindly furnishing information and data upon which this paper is based, and also the many samples, that will tell just what the article is far better than I am able to describe it.

THE FREEZING PROCESS OF MAKING EXCAVATIONS.

By Edward L. Abbott, C. E.

[Read before the Boston Society of Civil Engineers, Nov. 20, 1889.]

As is frequently the case with many radical innovations, the freezing process of making excavations in wet ground was at first looked upon as an ingenious idea, more interesting on account of its novelty than utility.

It was invented in Germany by Mr. Herman Poetsch. It met with some prejudice from those to whom it might well have looked for its principal support, namely, Mining Engineers, who did not realize that the first application must necessarily be of the nature of an experiment. No application of the process has been made yet, which did not result successfully; and it has now passed the experimental stage, and is entitled to a place among established processes of engineering.

An engineer sent to this country in 1884 to introduce the new process, was fortunate in meeting with eminent engineers who recognized its merit.

The first technical description appeared in the *Engineering News*.

The American patents were purchased by Sooysmith & Co., whose specialty was pneumatic work, but who now use either process according to the circumstances of the case.

The principle is becoming so well understood that a long explanation is unnecessary; it consists briefly as follows:

A series of vertical pipes are put down into the rock or into material impervious to water. These pipes are arranged around the space in which the excavation is to be made, and are closed at the lower ends. There is in each an inner pipe open at its lower end and extending nearly to the bottom of the outer.

Through these pipes a cold fluid is circulated by means of a pump, this absorbs the heat from the surrounding earth, and freezes it as hard as sandstone rock, most effectually cutting off the water. Then the excavation can be readily made without any trouble from water or flowing ground. Quicksand when deprived of its water is an easily worked material. The best arrangement of pipes is in a circular form so that the frozen wall will be arched against the pressure. The practice has been to use pipes 8 inches in diameter and about three feet apart. The crushing strength of frozen quicksand has been determined to be from 700 to 1,000 lbs. per square inch. The pressure from without, due to the weight of quicksand, cannot be known closely as the mobility of the material is not known in advance. The assumption can be made that the pressure will be somewhere between that due to the weight of the water and the weight of sand and water combined, considered as a fluid. For safety the latter assumption should be made.

Experiments are yet lacking and needed to show what is the actual heat conducting capacity of saturated soils. It is known that there is generally a current of water percolating and flowing through ground saturated with water; this current keeps taking away the cold from the pipes and an excess must be constantly supplied, and the circulation of cold brine kept up throughout the time that the frozen wall is needed.

Refrigerating machines of the common types depend upon the principle, that when a gas is compressed its temperature rises, and conversely when it is allowed to expand its temperature falls.

Ammonia is found to be the most economical gas to operate with on account of its high specific heat.

There are several types of machines. In the compression type the ammonia is compressed mechanically, and in the absorption type it is compressed by the tension of its own vapor heated in a still, which still communicates with a coil of pipes immersed in cool fresh water which gives a fluid cooled to approximately the temperature of the cooling water, say 60 deg. F. while remaining at the pressure of the gas within the still.

In either type of machine the compressed gas is cooled in the same way, and is then allowed to expand through other coils, when its temperature immediately falls to a point far below zero. This gives the refrigerating effect of the machine, and the very cold gas may be circulated directly where the cooling is desired, or may be made to cool brine, which is more convenient to use as the circulating medium.

The actual efficiency of refrigerating machinery, as now made, and working between the limits usual in practice, is not over 25 per cent of the energy applied.

The mechanical equivalent of changing the temperature of a pound of water one degree, is 772 foot pounds, or one horse power per day of 24 hours is equivalent to changing 61,554 pounds of water one degree F. Taking a pound of water at 60 deg. F. there are required 28 thermal units to reduce it to the freezing point, and then 142 more to freeze it, or 170 thermal units in all. Theoretically, then, one horse power per day would freeze 362 pounds.

In quicksand where only a fraction is water, and the remainder having a specific heat of only $^1/_5$ as much as water, the same refrigerating effect which would freeze a cubic yard of water will freeze say 2½ cubic yards of quicksand.

The first application of the process in this country was at Iron Mountain, Michigan, where a shaft fifteen feet square was sunk about 100 ft. to the rock ledge through water bearing strata.

The site is a valley filled with glacial drift. The shaft is for pumping and hoisting from the Chapin mine, the owners being the largest producers of Bessemer ore in the Menominee district.

Twenty-seven eight inch freezing pipes were arranged in a circle, 29 feet diameter. An ammonia ice machine of the compression type was used, its capacity being twenty-five tons of ice or fifty tons refrigerating capacity per day. The wall was frozen and the excavation made to the ledge in two and one-half months from the time the ice machine first started. On starting the machine the earth commenced to freeze in the

form of cylinders surrounding each pipe. In ten days these cylinders were in contact, forming the frozen walls. From that time the freezing advanced within much faster than without the circle, for the reason that no heat could be conducted to the center by the surrounding mass, and also the currents, or percolation of water through the sand could no longer warm the earth within the circle.

The unfrozen center became narrower as the excavation proceeded, requiring much difficult labor in loosening the frozen material. It was not considered wise to discontinue freezing, as trouble was anticipated at the ledge on account of springs or leaks coming in through the rock, and later developments justified this idea. Those strata of earth containing much water were frozen to much less distance than those containing little water.

Boulders were met with at different points. They were so firmly imbedded in the frozen mass that they had to be broken in pieces in order to remove them. It is proposed for the future to put in thawing pipes, as well as freezing pipes, in order to thaw any excess of frozen material to facilitate excavation. When the excavation was approaching the ledge, it became evident there was a leak, either in the ice wall or through the rock. There was an inflow of water requiring frequent bailing to keep it cleared. About the time the rock was reached the leak had thawed a channel at the rock line so as to allow such a stream of sand and water to enter as to necessitate flooding the shaft until the leak could be frozen off; but on pumping out the water other springs through the seamed and shaly rock showed themselves, and it was necessary to lay freezing pipes against the surface of the ledge, and again flood the shaft and freeze a considerable part of the rock surface itself before the excavation into the sound rock could be completed, and the timbering built in. This trouble would probably have been avoided if the freezing pipes had gone a few feet into the rock instead of only to it. In the case of a shaft now being built at Wyoming, Pa., the pipes are sunk six feet into the rock. In putting the pipes down it is of great importance that they be truly vertical so there will be no wide spaces between pipes at the ledge where there is the greatest necessity for a perfect wall, also the pipes must be absolutely tight or the circulating brine will escape, and as it cannot be frozen, it will keep the earth thawed near the leak.

In order to sink a pipe it must, of course, be open at the bottom, as various tools must be worked inside of it. A perfect closure of the bottom then cannot be made, therefore in practice a ten inch casing pipe is put down the required depth, and then an eight inch freezing pipe is placed inside, having its bottom perfectly closed by welding. The circulating fluid from the ice machine is a brine made with calcium chloride which has the advantage of a very low freezing point, together with a high specific heat and also is nearly neutral in its character, and does not corrode the iron pipes. It is circulated by pumping down an inner pipe and returning by way of the main freezing pipe to the cooling tank to be again cooled. The best results are obtained from such a rate of circulation that there is but little difference in temperature between the outgoing and incoming brine. A very efficient temperature for the outgoing brine is 10° below zero F. and pumped at such a rate that the return flow is 2° higher.

The capacity of an ice machine varies as the temperature at which it is made to work. Its theoretical efficiency will be very much greater when worked at twenty degrees above zero than when worked at twenty degrees below, but at the extreme low temperature the conduction of the cold from the pipes through the earth is greater, so there must be a compromise made between theoretical efficiency of the machine, and actual conducting efficiency of the ground. Sufficient experience has not been obtained to give a close idea of what this temperature should be.

Of all kinds of work for which the skill of the engineer is called into requisition, that of making excavations in earth, where a head of water is to be resisted, is conceded to be the most troublesome.

The name quicksand is given to any earth which, when mixed with water, will in some degree run like a fluid. Almost any sand when mixed with a small amount of clay will exhibit this faculty. The most troublesome kind has but a small percentage of sand and that very fine. The material being principally disintegrated soft rock. When rubbed between the fingers scarcely any grit can be felt. This material when undisturbed may have some consistency, but when once broken will flow with water through any minute opening. Its particles are so small and their specific gravity so light that they will float in the current of water to any distance, so long as the velocity of the water is kept up.

In excavations in running ground the great difficulty is not so much in keeping the water out as in preventing damage from quicksand shifting in its bed, which is likely when water is pumped from the excavation as it destroys the equilibrium of the mass. In the case of deep excavation, like shaft work, it will bring an unequal or bending pressure on the walls of the shaft which destroys its alignment or ruptures the shaft entirely.

In the development of the resources of any country, it is obvious that the nearest and most easily worked deposits will be opened up first, and similarly in all constructions for first internal improvements, easy and temporary expedients will be recommended as giving immediate results. That period of construction has already passed in this country.

The freezing process comes in its proper time to assist in some work urgently needed.

Deeper and better foundations are needed for bridges which will cross the great alluvial rivers—as the lower Mississippi. Tunnels are required under rivers where the importance of navigation must prohibit bridges—as across the Hudson at New York. The development of a good portion of the anthracite coal fields of Pennsylvania is yet to be accomplished which the overlying quicksand has, until now, prevented.

In the kinds of work mentioned, the pneumatic process has been very valuable, but the depth at which it can well be used without causing loss of life or health is not great, and the freezing process is the only reliable method of penetrating water-bearing earth to the depths to which it is necessary to go to carry out many great works which the further development of our resources and commerce now demand.

AMERICAN AND FOREIGN RAILWAYS.

By Willard Beahan, Member Engineers' Club of St. Louis.

[Read March 5, 1890.]

"But how the subject theme may gang,
"Let time and chance determine;
"Perhaps it may turn out a sang,
"Perhaps turn out a sermon."

—*Burns.*

How is America divided? You need not recall the colors on the map of your old geographies. A geography is never up to date, and all the tints of the rainbow do not suffice to faithfully portray a continent in its shades of possible governments and civilizations. America is to-day divided into two parts—Yankee America and Castillian America. These are its *grand* divisions, and no geographic line is possible to show strictly the demarkation. The railroads then of Castillian America are really *foreign* railroads to us.

In all railroad matters a Yankee railroad man considers that beyond all "probable, possible shadow of doubt," *we are the people*. Patent as this may be to us that we excel in our railroads, it is still a fact that what we do not know would make a goodly sized appendix to the volume of our present knowledge. And, wise is he who goeth abroad with eyes ajar and lips sealed seeking light and eschewing the tooting of the trumpet which hangeth at his girdle until a season more seemly. The less noise you make, the more you will hear. True, we are smart; and the attack is fast becoming chronic. Knowledge comes from seeing and reflecting, and knowledge cures smartness. Our railroads will, before long, lessen in rate of growth. Competition is getting crucial. Our pioneer railroad engineers and managers have gone over to "the silent majority" for the most part; and those still with us are beyond active service in inclination or through promotion. My judgment is, that to locate the lines built in the last decade has cost us fifty per cent. more to do the work indifferently or badly than it need to have cost to locate those lines well. That the construction of the lines of the last decade has cost twenty-five per cent. more than necessary to secure as good a road. That the maintenance of way of the railroads of this region offers the greatest field to-day in railroad economics—greater than transportation or traffic. The time is passing away when a graduate transitman can locate a railroad, a superintendent of construction build it and a veteran section foreman expend properly in maintaining it what a stock broker thinks best to set aside for betterments after paying *his* fixed charges. What is coming? It is time for thought and for going about with our eyes and ears open. Never mind boasting of what we have done. Granted that no nation before ever did so much—we must also grant that none before ever had such opportuni-

ties. The second admission detracts much from what is implied in the first. Our newspapers and public journals teem with the praises of the Yankee railroad man. But those of us who have toiled up from the ranks to those positions that reliability and experience give us will wear our epaulettes modestly. Counted strong, we know our weakness. There are other railroad worlds to conquer, some of which are not yet fully explored. A lusty, rapid, noisy growth is ours; we have yet to learn to think and to plan and to study much of the alphabet of economy. Some of you will take exception with me on this point. Yes, I do consider that to operate a railroad at sixty per cent. of its earnings is not bad. But stinting is only *one* ingredient of economy. Our lavish and lax methods begun before the civil war, emphasized during that war, and which ran riot until '73, needed strong hands and clear heads to correct them. We sorely needed in the west a Talmage to show us at how low a cost transportation on railroads could be done. It was as necessary for a Hoxie to teach us how cheaply a road could be maintained and administered; and that far above the strife between stockholder and employee stands the rights of the American people, which none who are wise will defy. *Public sentiment is might.* Men like these with their compeers who are gone or going, are strong, and have left their imprint on the railroads of America which will never be lost and but tardily forgotten. Clamor could not harm them. Had this class of men been less open to criticism they would have been less valuable. It is given to us that we follow, and we can stand upon their shoulders if we have sense. Surely a great point of vantage is that! We should cherish their maxims, study their methods and silently shun their errors, while we are grateful for the shrewd insight and unflinching will they manifested. What next? We can spend less, we have learned. When and how shall we spend it? To stand still and copy our predecessors as some are trying to do, has made them swearing trainmasters, drunken superintendents and bull-headed road-masters. *Any fool can reduce the force.* We are missing the kernel of the wisdom handed down to us and accentuating every vice and weakness that were but its unhealthy excrescences. It is now opportune for theoretical railroad men to become practical. If you really know anything worth knowing about a railroad and have that wisdom grafted securely upon sturdy common sense you are wanted.

Broad observation cures many ill tendencies; other horizons have a climatic mental effect and are good for our professional systems. Through the generous charity of our efficient secretary, I have been invited to take you for a 15,000 mile trip by sea in order to visit certain foreign railroads and see them as I saw them and think of them with me. No time offers me to look up authorities now, for what I was told, or thought I saw. We must each one do it for himself wherever we feel sufficiently interested. We should, no doubt, study foreign roads more. Mr. Dorsey has done much to attract foreign study to us and the time is ripe for comparisons.

We will take a Pacific Mail Steamship from New York City for the Isthmus of Panama. The sixth day out we are sweltering off the island of Cuba, with its green rugged walls showing a steep coast line, apparently. We touch nowhere and the ninth morning finds us anchored off Colon. They disregard the name of Aspinwall we gave it after Thomas Aspinwall,

so prominent a New Yorker in the building of the Panama R. R., and name it for Columbus (Christoph Colon.) We see a low-lying beach. The Atlantic slope is flatter than the Pacific slope here, as everywhere. The town and railway terminus is on land so low as to be naturally under water at a high tide and is probably in part a delta of the Chagres River. We are tied up at the pier and go on shore, the train of the Panama R. R., that meets specially each steamer, is awaiting us. The Panama R. R. is a Yankee American R. R. on the soil of Castillian America. Built by Yankees, its office must be in New York and its president a Yankee. Gen. Newton, of New York, holds the position, although the French now own the road,—a needed auxiliary to their canal. Col. Rives, formerly of the Georgia Central Ry., is superintendent of the road, and its operatives are American, in the unqualified sense, and of all shades of color. Yankee rolling stock, English rails and Castillian ties of lignum vitæ. Standing on the rear platform of the train, you pass up the valley of the Chagres River, which has the distinction of giving its name to the deadliest of fevers, you are first struck with the dense and enormous growth of vegetation. You cannot see through it; you could only walk through it with great difficulty. You begin to see why so many of your countrymen lost their lives here even in the surveys. It is perpetual twilight to a transit here; and reconnaissance is groping in the dark. As you pass up the Chagres Valley along the Panama R. R. you are going *east* to get from the Atlantic to the Pacific Ocean. The gradient seems about one per cent as a maximum and your maximum curvature about six degrees. The English iron rail seems low in height and is some lower than our own rails of like (56 lb.) weight. You see here and there tracks of the Panama Canal Co., with their French rail—as much higher than ours as the English rail is lower. The French rail saves ties, but is liable to overturn. Their overturning is much complained of by canal foremen.

A roadmaster climbs up and keeps you company on the rear platform. You mutually *spot* each other by that freemasonry through which old train and track men recognize one another the world over. Why is it that wherever we are the first question a railroad man asks us is, "What road do you work for?" You may wear the broadbrim of a Kansas plainsman, the suit of cords of an English tourist and the tan of a Texas ranger, but *anywhere* on earth, the moment you put foot on track or train, a brother, native to that road, says: "What road do *you* work for?" This roadmaster says these lignum vitæ ties are indestructible through age or decay. That they are bored to admit of driving the spikes, and that they are gotten in United States of Columbia at a cost not in excess of tie cost here. I understand they are more available than other ties there. It is a fairly ballasted road—mainly broken rock. The bridge masonry is not bad. Trusses a little antiquated. A very fair road, indeed. The canal business has so increased the earnings that the road has improved very much lately. Where but few sidings were many now exist. One wonders that a little fifty mile road with such small obstacles in its way should cost so much in life and money. Leaving the Chagres, we reach the backbone of the continent at Culebra and in another half hour are at Panama—a smart town, progressive and attractive. Here the Rio Grande River empties into the Pacific. It, with

a prong of the Chagres, is the topographical reason for the Culebra saddle we went through.

But can we not see the Panama Canal, you ask? Well, you can see little else from the railroad; but this is not a canal paper, and our journey is a long one scarce begun.

Our steamer is lying five miles outside Panama, and the canal will require a dredged harbor. As we go out on the lighter you are struck with the beauty of the site of the town of Panama, with its rising ground and bright green verdure—perpetual summer.

The anchor weighed, you bear away to the south along a bleak, abrupt coast having no railroad facilities. You pass up the Guayaquil River of Ecuador bound for the port of Guayaquil. I learned of no railroads in Ecuador save some short roads in the interior. A railroad is a plant not indigenous to a tropical climate. But you catch sight of the Andes that have so far successfully defied the iron highway. Your first sight of the Andes you will not soon forget. Close by the sea they seem to begin. One above another:

> "Hills peep o'er hills
> And Alps on Alps arise."
>
> —*Campbell.*

We are told that these are but foothills, though they be above the clouds. Chimborazo may be sometimes seen to the northeast. You stop at Payta, and to your query what could have induced a town to spring up in so desolate a spot, you are told that whalers could get water only here for a long distance. This shows you how few the ports and how scant the water on the Pacific coast. The Pacific coast of South America has very few good ports and not many even passably good ones. Iqueque, which we are told Mr. Blaine endeavored to secure for the United States, is the best port on the Pacific coast of South America. Of fairly good ports, there are not more than six, and some of those are artificial. This fact, together with the fact that the Andes range is quite close to the ocean all the way, renders the west coast of South America far less attractive as a field for the railway engineer than the eastern coast. Usually, the roads we see are but short, leading from a port or open roadstead back no great distance to some town on the first bench of the Andes, and often only to the mines of copper or nitrate.

As I recall, we see the first railroad south of Panama, near the port of Pacasmayo in the northerly part of Peru. It is not long and extends to and, I think, beyond Caxamarca. We next see the Chimbote railway, a short one back to the mines in the mountains. As the steamer approaches these small coast railways of this region, one's attention is first called to the poor harbor. You always anchor a good portion of a mile away and use launches rowed by eight men or more to transfer freight or anything beside passengers and light luggage, which can be carried in a small rowboat. These launches carry their loads back to quite long piers, which are made necessary by rocks or shoals, in securing sufficient depth of water for even these lighters. The pier is a curious affair, usually built of iron piles which consist of two track rails put together base to base, strapped as if under traffic, and these bases riveted together every two feet on each

side. They are pointed in a forge and driven by a pile-driver. They are placed four or more in a bent, have cast iron caps to carry string-piece, and are X braced with yokes at the intersections. They are then floored over, and make a fairly good pier to which you must not need to tie any vessel. These little roads have English rails and rolling stock, usually. They are not narrow gauge as a rule. This craze never struck Castillian America. They actually think there that on a sharp curve and rough track a car on a narrow gauge is more apt to upset. They really believe a heavy mountain engine should run on a broad track, and on 15° curves, have never discovered that a broad engine on a very short wheel base is more destructive to track than a narrow gauge engine on a long wheel base. These people have actually blundered upon what it has cost us millions of dollars to discover and barrels of ink to discuss. Yankee cars are looked upon with favor. But our engines are not adapted to these steep grades—often four per cent and sometimes six per cent for a short distance. The great engine there is a double-ended Fairlie. For roads such as these I can not see how anything better is possible to be devised. They have large grate-room; are very heavy in percentage on their drivers, but still not severe on track. But their greatness on steep grades lies in the fact that their boilers are short and each tube covered throughout its length with water. They are slow—not over twelve miles an hour there. These people have anticipated Mr. Wellington and climbed on the switch back principle, for which these "double enders" are well adapted. A switch back is a slow freight road. I can not conceive of a "Chicago Limited" or "Overland Flyer" traversing one. As a locating engineer, I should crave something better.

At Callao we see the center of quite a system of coast roads extending north and south of that port. The line into the interior carries you in a few hours to Lima, and you may pass beyond by rail to and across the Verrugas Viaduct, erected by Buck under Evans. The center pier went out six months since, There were an even number of spans and the cross-section was symmetrical. Henry Meiggs here made the most serious attempt thus far to cross the Andes. It is still attempt, only. The Andes are so much higher than the Rockies and the distance available so small in which to overcome that altitude, that it is no easy task. You see at Lima about 5 ft. 6 in. gauge, good English rail, coarse gravel ballast and used in that abundance peculiar to South America. The cars are English sometimes—more often from the United States. Our freight cars are counted far superior to their competitors, but our passenger coaches have a stronger competitor in the English compartment coach because a Castillian senorita is so very exclusive. Save the Fairlie engine for grades beyond two per cent, I consider to-day that the Baldwin and the Rogers engines have fairly outstripped all competitors in South America. English and Scotch "drivers," as they term a locomotive engineer, prefer our engines—say they will pull more, run faster and keep in order easier. Going south from Callao we are soon at Copiapo, a road of which W. W. Evans was once chief engineer and remained its consulting engineer until his death.

We are now in Chili. At Coquimbo there starts a road built about

thirty years ago, or less, to Ovalle. It was built and is now operated by an English company. On that road there is a double letter S climbing to the summit. It is the best piece of railroad location I ever saw and I regret that I cannot now give the name of that locating engineer. The gradients are equated for curvature. "Where are you most likely to stall?" I asked the engine driver. "Nowhere. It pulls the same all the way up." Of how many of us can this be said of each of our summits climbed? And this man worked a quarter of a century ago. You land at Valparaiso, the principal Chilian port. You ride inland to Santiago, the capital city. The road was begun in the 50's by Englishmen, I think. They delayed. Allen Campbell, of New York, then located the most difficult part and built much of it with Chilian capital, I think: This failed. Englishmen again began and changed Campbell's location. Finally, Henry Meiggs, a meteor of ours once seen throughout that coast, completed it. You now see English engines, cars of a mixed class, but mainly English —a Pullman parlor car (here called Spooner cars from their owner's name.) Rails are English and ties native wood. You do not run over twenty-five miles an hour. Your train is not handled by despatchers but by time card rights and sent from station to station by agents if you get behind and lose the right of way of track. Freight trains are slowly moved and the capacity of the road is much smaller than necessary. Everything is substantial. Of course, your track is broad gauge— here 5′·6″. You are in no hurry. All feel independent. Such is a Chilian road. Such, too, in the main are government roads everywhere. From Santiago there stretches away their Southern roads which W. W. Evans started for them. Rolling stock from this country is used, otherwise, it differs none from the Northern road just described. There are in Chili about 1000 miles of railway—mainly government roads. Complaints are rife of freight tardily carried; otherwise they serve fairly well. Locomotive engineers are British and the worst on earth. Other trainmen are natives. Maintenance is done by civil engineers. Yankees have done much of it with Chilian assistants. The Chilian civil engineer is not bad, when you consider his little experience, and is improving.

We must hurry on. We pack our mules carefully at Los Andes, the end of the Chilian Railway, and the foot of the Andes. We are bound for the Argentine Republic, and it is 225 miles by pack trail over the Andes to their nearest railway terminal. We pass up along the Cordillera River and the new grade of Clark's Trans-Andine Railway is always in sight. Clark is an Englishman who has a concession from Chili and the Argentine to join their railways. He has been at work two or three years. He uses a four per cent. grade and says his tunnel will be the longest in the world. That fact endears it to the Castillians. At 2 A. M. of the third day out you start through the snow to cross the summit. It is bright moonlight and the snow-covered, rugged Andes, towering away above you still, give shadow effects that bring words of admiration from even a prosaic railroad man. You are breathing hard as you reach the summit at Uspallata pass, 13,000 feet above the sea. You see a triangulation station of the Trans-Andine Railway line, at the summit, leave the snow and Chili and step at once on bare ground and the Argentine soil. A useful hot bath in

a natural spring and under a natural bridge refreshens you at that night's stop; you roast on the Pampas four days and ride into Mendoza and see the end of track of the Argentine railways. Of this trip across the Andes much is said in those countries. Its hardships consist of some forty mile stretches without water, of sleeping out of doors in the cold and of scanty food. You subsist mainly on dry bread and a species of dried beef called Charca. If you are inured to discomforts the scenery will well repay you for the effort. The dangers consist in the liability of being caught near the summit in a sleet storm. Every little way you see a stake where lies a victim to bravery—the snow his winding sheet. The streams are torrents and are deep and dangerous at times.

The Mendoza repair yard is an engine graveyard. There are "Rogers" and "Baldwins" there built in 1886 which their makers would scarcely recognize. Corroded and scaled by the worst of alkali water, burned out by coal, cordwood, Cardiff bricks and mesquite roots in mixed diet and covered with rust and dust, and leaking at every connection and cobbled up in every possible way, they look pitiable. These freight engines will start out to-day. The run is about 500 miles for a round trip, and they will be looked for back one month from to-day. Our own engines are used in the Argentine Republic usually. Anyone runs them: you have seen the men are not equal to the no easy task in the west. Our cars are, as a rule, used. Rails are European, of course, laid to a gauge not less than our standard. The ties here are iron. I understand that it is the principal railroad in the world using iron ties for a great distance and a term of years. They therefore deserve more than a passing notice. As we have been traveling some hours now by rail out of Mendoza let us examine these ties at the freight wreck we are being transferred around. The ties are so completely buried by the earth when in the track that it takes a wreck to exhibit them. They support the rails at a metre's distance apart. A tie consists of a support under each rail, and these supports are tied together by a wrought iron rod, ½ inch by 2½ inches, that is keyed to the supports. Each of the two supports consists of an iron casting ½ inch thick and shaped like a meat platter; or, if an ellipsoid be cut by planes parallel to its major axis, so as to divide the minor axis into three equal parts, the two outer sections would make a pair of supports. Each is about 20 inches long and 9 inches wide and is placed with the convex surface upward. Two projecting lips hold the rail on one side. A slot into which is driven a corrugated key of cast iron holds the other side of the rail. The castings are dated 1884, are made here and have been in the road since built. These ties are destroyed much less by this wreck than you would expect. Looking at them, I should judge a tie complete to weigh 150 pounds. It is a mud road—no ballast. The track is in good condition. You have seen that the earth cannot work from under them. Why are these not good metal ties? We ride over them several hundred miles. At each shop they make the castings. You can see here and there another tie made of a thin plate of mild steel. Take a wooden log the length of our ties, remove the bark from the upper third as it lies on the ground, bend the ends down for one foot and flatten them out there and you have this second kind of iron tie. Catches, only, hold the rail to

it. The ties have to be slid on the rails from the rail ends before laying the rail; if I saw aright.

You are riding along through the Argentine in an antiquated Pullman and it is some 600 miles from Mendoza to Buenos Ayres. The country is like Texas, Kansas or Nebraska. A plainsman from here feels at home there. You watch the railroad location work and do not detect apparent grievous faults. These roads resemble ours of western Texas. Reaching the eastern part of the country, you see a land most beautiful and fertile and prosperous. In 36 hours from Mendoza, you are at Buenos Ayres, the capital and principal seaport. The Argentine Republic is the greatest republic in the world after our own, and in time is sure to become easily the controlling power in South America. We have seen a considerable portion of its railways. The lines are none of them old. This is in their favor. Again; the country is easy for the locating engineer. On construction, wood is expensive, little is used in structures. Maintenance is a simpler matter. Yankee engineers have been there from the first and the rest have been English. These are the two best nationalities in railroad engineering. Aside from metal ties and a quite elaborate shop and terminal plan tendency, these resemble Yankee roads closely. There may in future come to us from that country some good lessons in railroad work.

A convenient steamer hurries you on board. You steam down the La Plata river and land at Monte Video next day. You walk about the streets of a quiet, conservative city, the capital of a non-borrowing country, rich in mines and agriculture; and whose paper money is worth as much dollar for dollar as our greenbacks. This is the first country we have seen on our trip, whose money is worth as much as our gold. At dark we weigh anchor and bear away to the northeast. We sight a penal island of Brazil, cross the equator, skirt the seas of Saragossa, and touch at the Cape Verde Islands. You are half way, and the first fortnight is over. You sight next the Peak of Teneriffe on the Canary group. It is plainly visible 75 miles off to-day. It stands above the clouds and is 12,000 feet above the sea level. The water at its foot is about the same depth. What majesty of height! You go on shore at the town of Las Palmas and stroll about in the ideal haven of rest for the antiquated physique of those engineers dame Fortune shall smile upon. You are away again, sight the Cape of Finisterre and pass into the English channel and the English fog.

You land at Boulogne, France, and rest your sea-worn stomach. Strolling through the yards of the Northern Railway of France there, you will first notice their freight cars. There are but two classes of freight cars in the world, I think. One class is Yankee—the other is not. This negative variety stands before you. It has high wheels—one pair forward, one in rear, and the axle boxes are rigid with the frame. The car floor is high above the track. The car is short—say fifteen feet, and carries a little more than half as much as ours. They are coupled with a three link and hook arrangement—like a coal or dump car. They are of wood with a roof of corrugated iron. A train carrying 1,000 tons of freight in these cars would be a longer train than ours, would weigh more

empty than ours, and would pull harder per ton of gross train on curves for it is on longer rigid wheel bases. The brakes are set with a lever 8 feet long lying alongside the car at the floor. It cannot be set while the train is running. They have a powerful brake in the caboose. Few brakes, and link couplings with much slack makes it a dangerous train to handle. This freight car standing before you is the only competitor of our eight-wheel, two-bogy freight car, whose rigid wheel base is less than that of a common street-car. The outcome of the competition, I think, requires no prophet to foresee. We will now look at their passenger cars. A passenger rides in a coach, anywhere outside Yankeedom. As you look at them, the cabinet work on the outside of a "coach" divides it into three perfect representations of an old horse coach. You step into the coach at a side door, as of yore, and you are in a compartment having one seat each side the door and running clear across the car. If it be a high class coach, three are seated each side, if of the lowest class, there may be eight each side. Compartments are entirely separate. Some now have an electric bell you can touch to call the guard (conductor) should you find yourself shut in with a lunatic or an ardent disciple of John Barleycorn. The smaller of these coaches run on four wheels like a freight car, but you may see in Europe many have a third pair of wheels placed midway between the end axles. In any case, the distance from centre to centre of these end axles is the rigid wheel base. All car wheels seem high to us there. Their coach bodies are not higher than ours. To carry 500 passengers on a train of these coaches and allow to each passenger a certain floor space would require a longer train and usually a greater weight of empty train than in our own passenger cars. Of course, in wheel base we save much resistance on curvature. Third class trains or workmen's trains may however show as low a car weight per passenger as our own rolling stock can show. We leave this latter question to Mr. Dorsey. Compartment coaches are not consistent with democracy. With classism they chime well, and classism unmans us all, makes us selfish and boorish. He who rides by classes will ere long shoulder a lady away from her rightful place in turn at the window to get a ticket. Be he prince or pauper or priest, it is all the same. In a word, mileage and a republican government will destroy the compartment type of passenger cars.

Our own engines are greater for us, certainly. Our car and locomotive builders stand more clearly in the front rank as compared with Europeans than do we civil engineers as compared with our foreign competitors. Our cars will ere long be the only ones save in dense, small, old countries. Our locomotives have a harder competitive task, but for all in all, they are unequalled. European engines have no pilots or cabs, are inside connected, have horizontal frames, are complicated in their parts—yes, but they have a fine roadbed to run upon that is well policed, and they are not manned by the tramp element. Put them on our track with our poorest engineers to run them, and they would never reach any destination but the ditch. But we must beat them on their own track and surroundings. Our strong points are useless there, in many cases. I

have done with rolling stock comparisons. As I have said, in rolling stock we *most* excel foreign railroads.

We are off for Paris. What a roadbed! How smooth! These bad cars jolt much less than our better ones at thirty-five miles an hour. No rear platform aids us in our study. Plenty of ballast, broken rail-joints, a track always fenced, gates at crossings always guarded, a woman each mile policing the track, the block system of operation, and rarely a track gang in sight, are the features of French track we see. In Paris you are struck with their complicated switches and yard systems. You see our own "puzzle" switch, but a more aggravated case of it; three tracks are handled at the same point of crossing, just as we handle two. The French are great in switches and in signal systems.

Ten days later we leave Paris at noon, and crossing the channel to Dover, reach London in the early evening. London, with its great fog above ground, and its great underground railroad beneath. The underground idea strikes me as the solution of the rapid transit problem in large cities, especially to their outermost parts. Their fastest trains run fifteen miles an hour. As compared with our elevated roads, these underground roads will have a greater first cost—a less maintenance cost—greater speed and greater capacity.

The difference between an English and French locomotive is not marked. The cars are similar, but the French have a fantastic kind or two not seen in Great Britain. We will discover no great differences in track. Yard systems in England are simpler. The French, a romance nation, do not shun a complicated system in anything as do the Saxons. You go out from London to Liverpool on the famous "Wild Irishman"—45 miles an hour, including stops. From timing trains both in France and in Great Britain, I concluded that they ran no faster than we do, even with such trains as the "Wild Irishman," and the "Flying Scotchman." Between terminals they make better time than we do, for these fast trains make but few stops and their tracks are so vigilantly guarded that through towns at which a train does not stop it runs at full speed. We lose time as compared with them at crossings and in streets of towns. You forget for the present the Liverpool docks you saw—the finest on earth—and leave for Edinburgh. Until you reach Scotland you have traveled in Europe in a country quite level, indeed, as a rule, and you have seen no great difficulties for the locating engineer. As you enter Scotland, the ground is more broken and often quite difficult.

While at Edinburgh, we must see the bridge over the Frith of Forth being completed as we look at it. You walk along the site and under it and see the first 12 feet of the masonry above ground. You hear the workmen and it is midday, but that Scottish fog as completely hides that bridge as though it were midnight. As your patience gives out so does the fog, and your first exclamation is "Enormous." The steel cantilevers rise above you 360 feet and the metal work is 1½ miles long. You see three cantilevers forming two clear spans of 1,710 feet each, the longest spans in the world. The outer arms of the end cantilevers are heavily counterpoised. It strikes you as a singular span arrangement, but the form of cross section explains it. The channel has 200 feet of water with the vol-

canic island of Inch Garvie exactly midway between the steep channel banks. The Creator pointed out pretty clearly what spán arrangement was wanted. So gigantic a structure is hard to grasp, mentally. Compression members are steel cylinders 11 feet in diameter and of plates ¾-inch thick. It is a double track bridge, owned jointly by four of the strongest railroad companies, and has been six years in construction. It strikes one as too massive and that both material and stability are in excess. The bridge, you must remember, however, was begun just after the Tay Bridge disaster. Could a different type of bridge have been used? You have 200 feet of water under your spans and you want 150 feet of clear head room for sea-going vessels. This makes, of course, false work impossible and confines us to the suspension or to the cantilever types. Would Mr. Roebling have attempted a suspension bridge there? Would it have been possible and more economical than Messrs. Baker & Fowler's Bridge? The question is beyond my knowledge. A two-span suspension, and at that height seems impossible to me, but as you look at that bridge with me, you will try and think of some way to save material and consequent cost. No foundation was over sixty-five feet below the water surface, and of this foundation thirty feet was in mud. The greatest pressure in pneumatic work was thirty pounds per square inch. The bridge is, then, all above the water surface. The masonry is Aberdeen granite, a light grey of fine grain. It is a very excellent stone. The four horizontal cylinders that act as struts between the four pedestals, which together carry one cantilever, are each 14 feet in diameter and built of steel plates 1¼ inch in thickness. These are the most massive members of the bridge. I have said that compression members—consisting in this type of the lower chord and the vertical posts and posts inclining downward toward the pier—are cylinders 11 feet in diameter. The tension members are heavy rectangular lattice girders. The track is carried through the cantilevers over 150 feet above the water, being a little below mid-height of the cantilever at its pier centre. Standing under the bridge you see the enormous stability of the cantilevers when resisting wind pressure. Those cylinders resting each on one of the four pedestals of a pier are given a heavy batter. Clearly no side wind of whatever force could overturn those cantilevers. Mr. Cooper, the resident engineer, informed me, the maximum wind deflection noticed had been ¼ inch; but that the sun and cold air acting against the bridge in the same direction had turned a cantilever 5½ inches. The cylinders resting on the pedestals were first erected. A traveler was used running on each top chord for the work later. Although the connecting girders are 350 feet long, the travelers came off the cantilever onto them in the usual way and with only one temporary tension and one strut member added. The steel was furnished by the Scottish steel works near Glasgow. It was cut and shaped, for the most part, at the working shops at the south end of the bridge. It was not contract work, finally.

We are off for Glasgow through the coal fields and furnaces that line the road all the way. The railroads are badly kept here—no second-class coaches and much untidiness. The thrifty Scotch are most provident. Still, they tire not of speaking of Scott, "Bobby" Burns and Highland Mary: of Aryshire, of Greenock and Dunoon. From Greenock you cross

over to Belfast and go via Dublin to Cork to see the Irish railways. To say that Irish roads are simply a poor class English road will sum up the whole matter. They have more water to contend with. No manufactories there make it hard for a road to pay and nicely prosper. A beautiful island is Ireland, a rich soil and one nature intended to be prosperous. Discontent with governmental affairs dins in your ears. The Scotch think first of making money. The Irish think first of governing themselves. One must see and feel these two peoples to realize the contrast in their temperaments and tastes. The difference between the English and the French is no more marked than that between the Scotch and the Irish.

We are waiting at Queenstown on Sunday morning. Our steamer for New York is lying in the offing, having left Liverpool yesterday. While we wait for the mail that left London Saturday night to arrive by train on Sunday noon, we will walk along the cliff roads and think over our object lesson. In Castillian America we meet no German engineers in any number on railroad work. We meet now many French engineers. But if an idea be not a Yankee railroad idea it is an English idea. We have seen that motive power, and rolling stock and operation in France differs little from in England. Practically, then, it is the English railroad pitted against the Yankee railroad throughout our journey. Now, strictly railroad engineering is of three kinds, location, construction and maintenance. In location work they use less curvature than we would use. They at least do less twisting and turning for trifles. They may not follow a correct general course. We lose too much distance — five to ten per cent too much. They chop grades much less. Still, our broken grades on minor gradients are not our worst faults, and are forced upon us to save first cost often. They are more careful, and their locations, "looking backward from the year 2,000" will be much less discreditable than ours. Their construction takes much longer. Our labor saving devices aid us. We can *at the best* move earth on grading a road for six cents per cubic yard. actual cost. We now grade for as low a price as they, perhaps, but should grade lower still. Stone and iron structures there can not be justly compared in cost to our wooden structures. We could do the iron work for less; the stone would cost us rather more. In ballast they far excel. Small mileage allows all foreign countries save the Argentine Republic to far outstrip us in proportion of mi eage ballasted and thickness of ballast. In cost of track we are abreast of them. On the whole, we should have materially the better of competitors in cost of lines like our own. In maintenance we are *very far* behind. Study the question as I can, there is no denying that we are fairly distanced. Our rail section I have greater faith in, but Mr. Whittemore has been making inroads upon my faith even there. Putting it all in a sentence. I think we neglect small repairs and pay a dollar to do now what could have done for a dime a month or so ago. Of course, they start out with a better road. But, see their enormous tonnage, mucky ground, rigid long wheel bases, no bogey trucks, and infernal couplings and brakes, with their higher average speeds. Then, recollect how few section gangs you saw. Notice, too, that you never see a little thing left undone. We never repair masonry till it has to be rebuilt.

Never touch track till it has needed it sorely, and then we raise it above the construction grade line until the crown of embankment is too narrow to hold a tie. We make a ditch, not by cleaning out a side ditch in a cut, but by hoisting the track and leaving all the silt in the ditch and under the track. Europeans ditch, and they sit on a track pry less. Their maintenance is in charge of engineers. But we haven't engineers to spare always to maintain our roads and few, indeed, who study that part of the work. The maintenance of way of Yankee railroads is the greatest economic railway problem to-day, *i. e.*, greater than transportation or traffic. In the handling of freight at stations, in the handling of trains, in rolling stock and motive power, we excel easily both in speed and cheapness. We are very great in transportation. In traffic our problems are cubic equations in algebra, while theirs are simple arthmetic multiplication. Finally, then, we need to work more studiously in location to save investing a dollar foolishly; and we must find how and when to make a dollar go much farther in maintaining our roadbed.

The London mails are here and wait for nothing. You begin now to feel the rush to which you are native. You go on board. In a week you sight the light ship off Sandy Hook. You march proudly up Broadway. You are home. Your thoughts are these: This, my people, have a good deal to learn yet, but this republic is the *proud hope* of the world to-day.

TRANSMISSION OF POWER BY MANILA ROPES.

By John H. Gregg, Member Western Society of Engineers.

(Read December 4, 1889.)

A dozen years ago, the factories in the United States, that were using rope gearing as the method of transmitting power, wherever it could be economically employed, could be counted on ones finger ends.

There were a few large cotton mills in the New England States, that were using the English system of separate ropes to transmit power from the prime mover to their line shafts.

In the past two or three years so prominently has the subject of rope gearing been brought before the public, that few large power plants have been erected where the subject of using this method of power transmission, in preference to any other, has not been seriously considered.

The sudden rise into popularity of rope gearing, is mainly due to its having been adapted to American ideas, making it possible to use this form of transmission in our present factory buildings; and also to the growing feeling of dissatisfaction with belts. So strong has this feeling become that rope gearing threatens to supplant belt gearing in public favor.

The English system employs independent ropes, so that if there are ten grooves in the sheaves, there are ten ropes, and ten splices to take care

of. The driving force depends on the weight of the ropes and the shafts are spaced not less than 50 feet apart, and slack must be taken out of each rope separately.

The American system employs one continuous rope, independent of the number of grooves in the sheaves, and an automatic tension carriage for taking out the slack and giving the ropes traction—the driving force depending upon the amount of weight put on the pull back.

The sheaves for rope gearing are of two kinds, drivers and idlers, distinguished from each other by the shape of the grooves. The groove for driving sheaves, that have been most generally adopted, is one in which the included angle is 45°. The ropes are not allowed to bottom, but get a very large traction force from the ropes wedging in the V grooves.

The groove for idlers or carrying sheaves is semicircular, the diameter of the groove being a trifle larger than the diameter of the rope.

Some of the advantages over gearing may be briefly stated as follows:—

1. The rope system is almost noiseless.

2. Ropes do not pick up the dust and dirt in the room and deposit it on the ceiling.

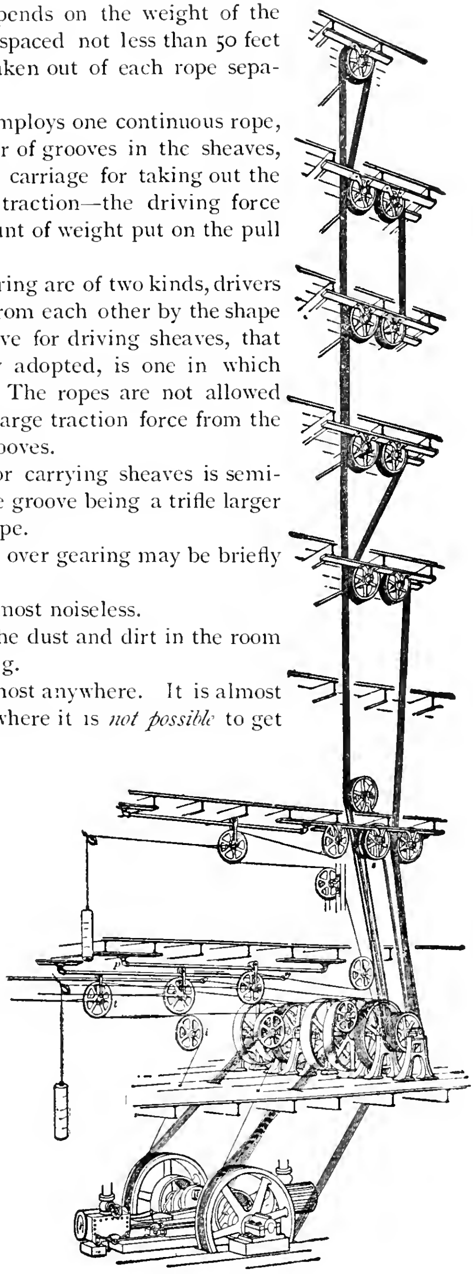
3. Ropes can be laid almost anywhere. It is almost impossible to find a place where it is *not possible* to get a rope.

4. For large powers, ropes are much cheaper than belts.

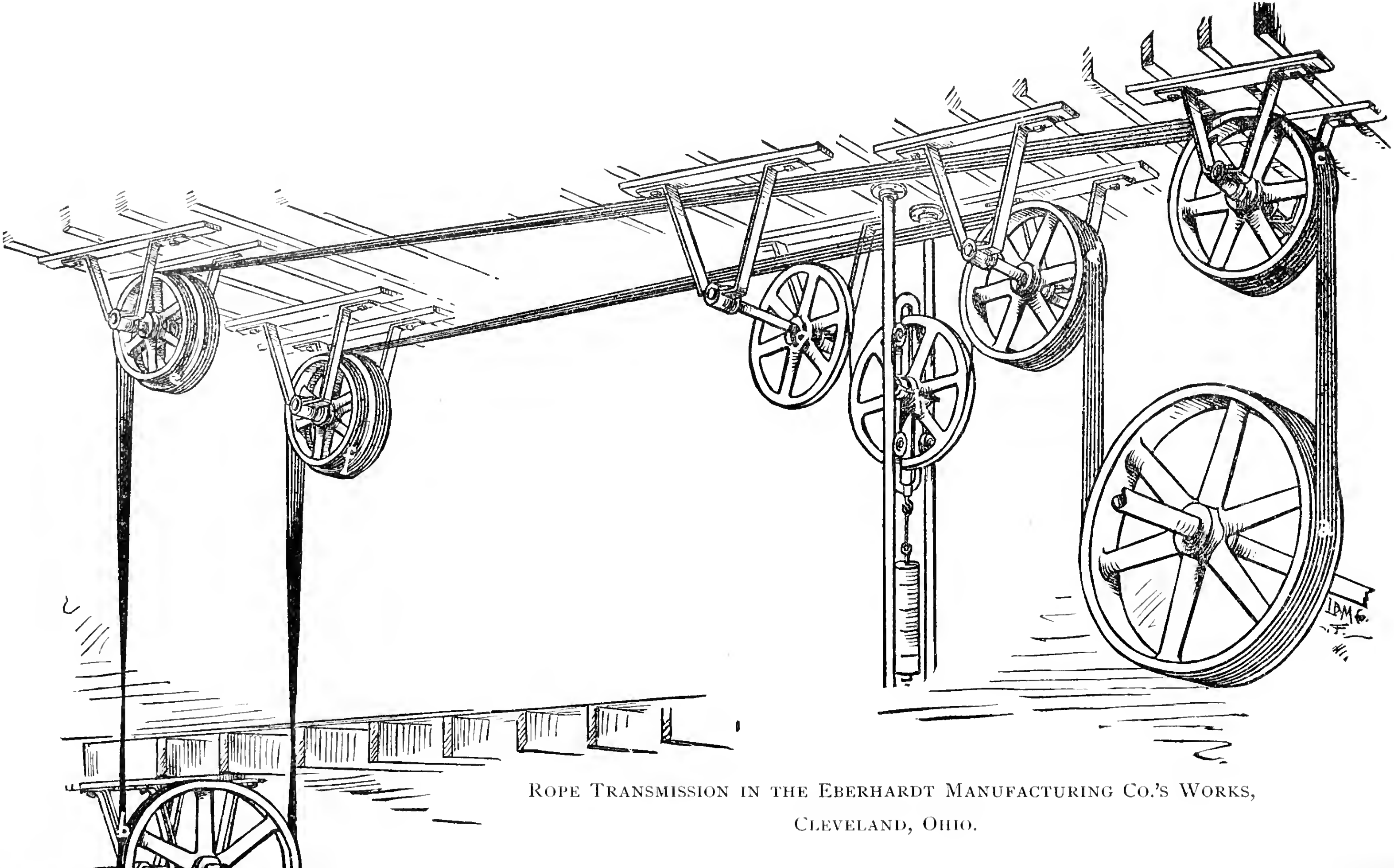
5. The tension on the ropes can be regulated with the utmost nicety, reducing journal friction to a minimum.

6. The driving and driven sheave may almost touch each other and still be successfully driven with ropes.

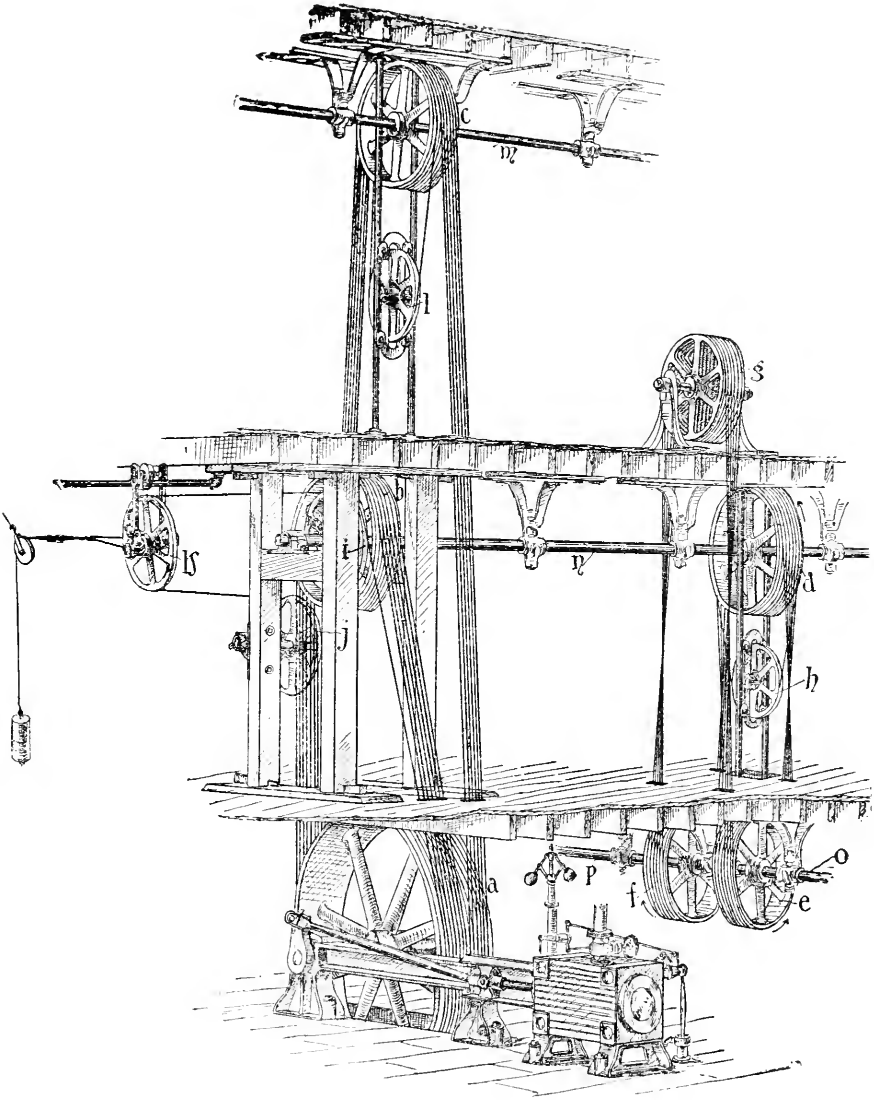
7. The driving and driven shaft may be out of line—in long distances—to an extent without affecting the durability of the rope.



MANILA ROPE TRANSMISSION IN THE NINE-STORY POWER BUILDING OF THE WESTERN ELECTRIC CO., NEW YORK CITY.



Rope Transmission in the Eberhardt Manufacturing Co.'s Works, Cleveland, Ohio.



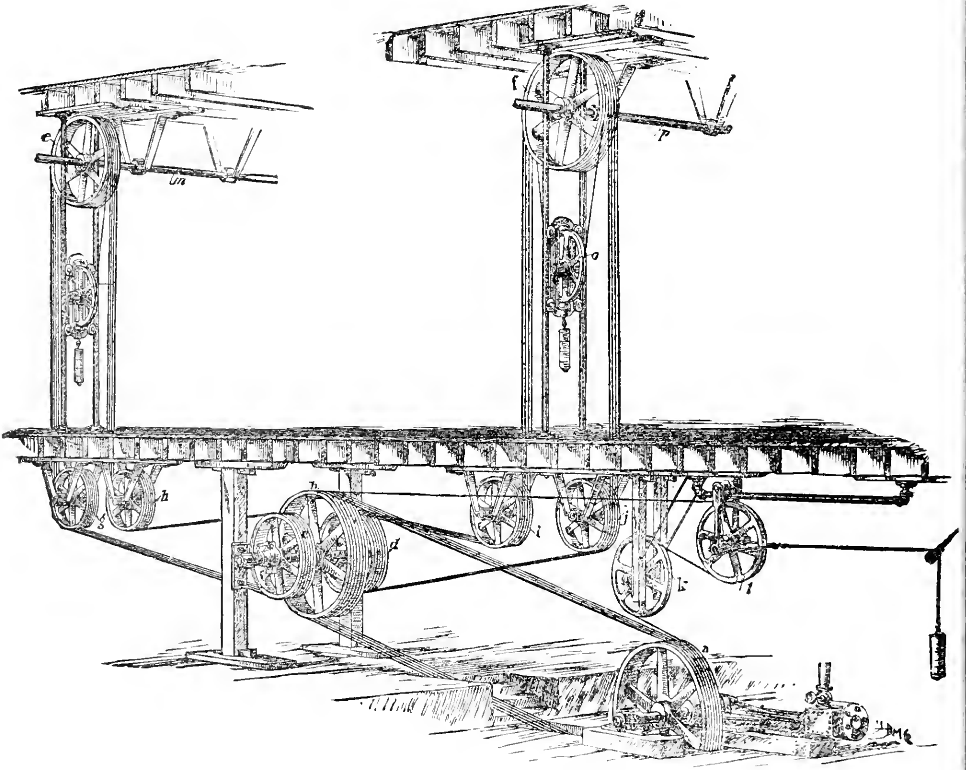
THREE-ROPE TRANSMISSIONS IN J. K. RUSSELL'S WORKS, CHICAGO.
250 HORSE-POWER ENGINE.

8. With properly prepared ropes they can be run as successfully out doors as in.

9. Power can be transmitted to long distances very economically.

10. About one-half the space is required to transmit the same power as compared with belts.

The power which ropes will transmit depends on their size and the velocity with which they are run. In a recent article Louis I. Seymour publishes a table compiled by E. D. Leavitt, Jr., who has made a careful investigation of the English and American practice.



THREE-ROPE TRANSMISSION IN THE LINK BELT ENGINEERING CO.'S WORKS, NICETOWN, PHILADELPHIA, PA.

The horse power of ropes according to this table is as follows:

FEET PER MINUTE.		1000	1500	2000	2500	3000	3500	4000	4500	5000
		HORSE POWER.								
DIAMETER OF ROPE.	¾ in.	1¾	2¾	3½	4½	5½	6½	7	8¼	9
	1 in.	3¼	4⅞	6½	8	10	11	13	15	16
	1¼ in.	5⅛	7½	10¼	13	15	18	20	23	26
	1½ in.	7½	11	15	18	22	26	30	34	37
	1¾ in.	10	15	20	25	30	35	40	45	50
	2 in.	13	19½	26	33	39	46	52	59	65

He also gives as a safe formula for ordinary practice, the following,

$$\frac{G \times D \times R}{200} = \text{H. P.}$$

when

G = circumference of the rope.
D = diameter of the sheave in ft.
R = revolutions per minute.

In the above table at 3,500 feet per minute a ¾ inch rope will transmit 6½ H. P. At the Chicago Arc Light & Power Co.'s plant they are running successfully 50 light dynamos with two ¾ inch ropes. The ropes travel with a velocity of 3,516 ft. per minute and transmit 50 H. P. or nearly four times as much as the power given in the table.

At the Western Electric Co.'s Chicago building, a single ¾ inch rope having a velocity of about 2,000 feet per minute has transmitted over 40 H. P. for nearly two years.

The difference between the English system of independent ropes and the American system of a single continuous rope with tension carriage may be readily seen by comparing the plan of the rope gearing as erected for Geo. Knowles & Sons, Limited, and the perspective sketch of the rope transmission as designed for the Western Electric Co.'s New York building, for although the power of the two plants are widely apart, the general arrangement of the two systems are still farther apart, and while in the English system a large independent rope alley is usually required, the American system takes up a comparatively small space.

The Western Electric plant was originally designed to transmit 150 H. P. through the several floors of the building and was to have two independent continuous ropes with separate tension carriages. Driving to the second floor with six ropes and to the floors above with six ropes making twelve ropes on the driving sheave. They have been transmitting over 225 H. P. with one of these ropes, driving with three ropes to the second floor, and three ropes to the floors above.

It may be of interest to here note that in the Western Electric Transmission each floor is provided with a friction clutch cut-off coupling by means of which in case of accident, on any floor, the power can be cut off without interfering with any of the other floors.

The other three perspective sketches given are examples of successful rope transmissions, also designed and carried out by the Link-Belt Machinery Co., of Chicago. The one designed for the Eberhard Mfg. Co. shows one of the methods adopted for driving shafts at right angles.

The tracing of the plant furnished to the Southern Pacific R. R. Co. shows one of the peculiar advantages of rope transmission. Here it was required to operate four widely separated barrel elevators and in no other way could they be driven so cheaply and so well as with rope gearing.

The ropes used for transmission purposes are made from the best quality of Russian hemp laid in tallow. They should be hard but pliable and perfectly smooth to the touch, having no rough or loose ends. The color is yellowish gray—black spots indicating fermentation in the process of

curing. It should be laid up in three strands, because three strand rope is easier to splice and there is less of the rope cut away in forming the splice.

The average breaking strength of the manila rope is about 10,000 lbs. per square inch.

SNOW PLOWS.

By F. E. Sickels, Member Engineers' Club of Kansas City.

[Read December 2, 1889.]

The action of the best form of old fashioned snow plow is to first lift the snow to a sufficient height and subsequently throw it to one or both sides of the track, by the action of the mould-boards. The machine consisted of an inclined plane with its lower edge within two inches of the track, with mould-boards or wedges placed upon this inclined plane, back of its front edge, far enough so that the action of these mould-boards would tend to throw the snow on top of the surrounding snow. The machine can be placed, if not of very large size, say up to nine feet in height, upon four wheels. The axles of these wheels should be very large, having bearings four and one-half inches in diameter, by eight inches long in boxes that are not fixed, but can slide up and down in the pedestal, and then if the plow is heavily loaded, say at the rate of four tons to each wheel, and made strong throughout, it will do very efficient service in all ordinary snow storms. The various accidents that have happened to this kind of snow plow have mainly arisen from causes not necessarily inherent in this plan. These plows have left the track, for instance, by reason of the boxes being rigid in the pedestal and the front end of the plow striking say, a mass of ice at a road crossing and lifting the front end of the plow up, the wheels are lifted up and the plow leaves the track. And again, when not heavily loaded they have left the track from lateral action, as they are more easily shoved off the rails. The history of the action of this plow when properly made, has demonstrated it to be a very effective machine in almost every case where a snow plow is available, though it is true that the rotary plow that is now coming into use is more effective in cases where the snow has drifted in upon the track, carrying with it sand, and subsequently freezing into a hard compact mass.

This statement is made here at the beginning, so that those who have no time or desire to go into the details of the history of snow plows, may have the substance of this article without wading through the whole of it. As to the history, probably the first snow plow used in the world came to be constructed from the necessities arising from the construction of the early locomotive and its application to the tracks of this country. The

locomotive, John Bull, was imported from England in 1831, and was tried on a short piece of road at Camden, and was declared a failure, as it ran off the track. Subsequently four other locomotives were made for the same track, and seeing the defect of the John Bull, leading wheels were put upon them so as to carry the head of the engine around the extreme curves. At about the same time, the John Bull was altered, and a pair of leading wheels were put upon it and other alterations were made. Then to provide against cattle on the track, the extension beams, upon which these leading wheels were placed, was provided with a platform, so arranged that any animal caught by the engine would be lifted from the track. The next winter, after these engines started to run, the snow having covered the track, the same platforms were used to lift the snow and mould-boards were put upon these platforms to throw the snow thus lifted on top of the surrounding snow, and this was the first railroad snow plow. Which one of these five engines the plow was first put upon it would be impossible to state, as they were all so arranged before a year had passed. The John Bull engine was laid up for some time, while the others were being built and placed in operation. Perhaps it would be well to mention that the John Bull engine, now in exhibition in the National Museum at Washington, is not as it was originally used with the platform in front. The first platform was straight across the track and extending upward on a level plane. The one now on the engine is made more like the modern pilot or cow-catcher. The reason of the change was, it was found that in running and catching an animal on the level plane the brute was lifted off the track, but subsequently upon slacking the speed of the engine it would tumble back, therefore it was changed into two inclined planes, much like the modern pilot, and hence followed the plan of making two inclined planes, so that as soon as an animal is struck it is thrown laterally from the track.

In all probability the experiment that was made at the commencement of the running of locomotives on the Camden and Amboy Railway, was really the beginning of the snow plow, the modern pilot, and the leading wheels to carry the head of the engine around the curves, and they all arose from the necessities which presented themselves in the comparatively early days of the use of the locomotive engine. Since that time there have been many devices invented for clearing the track, but all the old fashioned effective ones have been substantially upon the principle of first lifting the obstruction and subsequently throwing it laterally by the use of mould-boards placed on an inclined plane.

Some snow plows have had remarkable records for their efficiency. A snow plow on the Boston and Providence Railway was used as required for clearing that track for twenty years, leaving the track but once in all that time, proving itself very effective. Of course, one element of success with the snow plow is to get to work with a good plow as soon as possible after the commencement of the storm. The speaker remembers having been snowed in for three days in going from New York to Philadelphia in the early days of railroading. At that time there was but one train a day and very few spare locomotives owned by railroads.

Some snow plows have been made very large, running on two trucks,

and were very effective in any ordinary heavy snow storms. It has been maintained that it is not actually necessary to load a plow to keep it on the track, as the snow coming upon it gives it all the required downward pressure.

This may be true to some extent, but the additional loading will tend to prevent it from leaving the track. One reason why the covered pilot is so effective in removing snow within its reach is because the wheels of the locomotive are held on the track by a very considerable weight and the engine can be run at a very considerable speed while throwing the snow off. Of course this only applies to snows of only thirty inches or less in depth. It has been a favorite plan to get up a high rate of speed when running into a snow bank with a plow of large dimensions. This will work very well where there is no ice or sand deposited with the snow. Accidents will happen owing to the want of sound judgment as to the rate of speed necessary, and when accidents have happened with the use of the old fashioned plow, the blame has been attached to the faulty construction of the plow, when the fact is, the accident would not have occurred if reasonable judgment had been exercised in determining the character of the snow. The old fashioned snow plow will clear the track at a low rate of speed, and at this low rate will very seldom leave the track. And a low rate of speed should be used in all cases where there is any doubt as to the character of the snow. Cases have occurred at road crossings after a thaw, the water having run down and subsequently frozen over the rails and a second snow having covered the ice thus formed, when attempting to clear off this snow the wheels have mounted on the ice under the snow and the plow has left the track. Again, when the wheels have crushed through the ice and held the track the rails have spread so far in crushing the ice that the locomotive behind has left the track, therefore great care should be exercised to determine as far as possible the condition of the rails under the snow when using a snow plow.

Then again, accidents will happen. owing to the breaking of the axles under the plow by reason of the enormous downward pressure of the snow. It has been too much the custom in making snow plows of the old style to use any old axles and wheels that may be on hand, whereas the axles should be larger than ordinary so as to insure strength. The front wheels should be placed as near the front end of the plow as possible to insure a load of four tons on each wheel. There is always enough room behind to get plenty of weight on the rear wheels.

The rotary plow, which is now coming into use, is a very old device, and all recent patents on it are simply upon immaterial details. It relies for its effectiveness upon the large amount of power required to work the rotary fans or cutters. The greater the power the more effective will be the machine. It will act in places where the old machine that has been generally used would not be nearly so effective, as, for instance, in cases where snow, sand and ice are mixed together; but the old fashioned plow can be built for about seven hundred dollars and the rotary plow with ample power will cost ten thousand. One great difficulty with the snow plow is that a road may have one for many years before they have occasion to use it, and the feeling formerly was to scarcely keep any kind of plow on hand for that reason.

But with the introduction of the Pullman sleeper and all the modern appliances for conveniance and comfort in railroading, the most effective plow, without regard to the expense, is now in demand. When the rotary plow was first built it was condemned, because, for the amount of money a company was willing to spend upon it, it was not nearly so effective as the old style, whereas, for the amount of money a company is now willing to spend upon it, it is more effective than the old style, as great power and strength is combined in the rotary snow plow as now built. The rotary plow cannot be run through a heavy bank of snow at high speed as it is liable to clog, and therefore the temptation to force is not so great as with the old fashioned plow, which can be driven very fast into a snow bank and the snow thrown to a great distance from the track if all is clear, as is usually the case in practice, though not always.

MISCELLANEOUS NOTES OF EUROPEAN TRAVEL.

By Members of the Boston Society of Civil Engineers.

[Read October 16, 1889.]

By E. D. Leavitt.

It may be interesting to the Society to know that I saw sound, solid steel castings of 50 tons weight, also other steel castings of the most intricate description, with metal thick, thin and cored, in the same castings which were entirely sound—articles that cannot be produced in America as yet. I also saw some plate girders for a traveling crane of box section, 60 feet span, and designed for a concentrated load at the centre of 300 tons. The columns which supported this girder had a base, on the ground, of 10 ft x 6 ft.; the cross sections of the column was about 6 ft. x 30 in., they were of double plate section and heavily ribbed. The building was some 600 ft. x 150 ft. wide, and was designed for a hydraulic forging establishment at the Krupp Works. Two cranes of 150 tons, each, capacity will run the whole length of the building.

Another interesting thing was the pouring of a crucible steel ingot, which was participated in by 400 workmen. The popular notion of "fife and drum" was dispelled, as entire quiet pervaded the whole operation, the superintendent's voice even could not be heard as he gave his directions. Two men took a crucible charged with 90 or 100 lbs. of metal and poured it, and were succeeded by two others; the consequence was that a continuous stream of metal ran into the mould, which held about 18 tons. There were fourteen furnaces, each of which held one-hundred crucibles (not all were used for this casting.) As fast as a crucible was poured it was thrown on the ground, and the men went for another. The heavies

ingots are cast in the winter, and they can pour 85 tons at one time, some 1,400 men being employed in the operation.

In Bohemia, at Kladnow, some twenty miles from Prague, I saw in operation the Brandt system of hydraulic boring. They were driving a tunnel through hard silurian, the same being, in cross section, 10 ft. 6 in x 6 ft. 6 in., and the progress made was 100 meters per month. The machines, of which there were two, bored two holes at once, some 2¾ in. in diameter, and 50 in. long without fleeting. The hydraulic pressure for operating the drills was upwards of 60 atmospheres.

At the same place [which, by the way, was a coal mine] I saw the most wonderful pumping machinery that it has ever been my fortune to look upon. 1,700 ft. below the surface were located two pairs of compound pumping engines, driving double acting plunger pumps of 28 in. stroke for one engine, and 3 ft. stroke for the other, raising the water against the whole head of 1,700 ft., and running at a speed of from 40 to 72 r. p. m. with entire smoothness. I could not see that it made the slightest difference whether they ran fast or slow as regarded the smoothness of their action. The pumps were the invention of Prof. Riedler, of the Polytechnique Institute at Berlin, and his system is coming rapidly into use on the Continent of Europe.

I saw similar pumping engines at the water works at Rotterdam, the regular speed of which was 60 r. p. m., the stroke being 3 ft. The head there was about 100 ft. and the pump worked with entire quietness, while the engineer of the works told me that the slip was hardly appreciable, although the valves lift about two in., and there is only one valve for suction, and one for delivery at each end of each pump.

I was very much interested in a visit to the electric lighting plant of the Berlin Company, one of the largest and best equipped in Europe. They have several stations scattered about Berlin, the smallest having some 3,000 H. P., and the largest being arranged for nearly 6,000 H. P. The dynamos are of the ring type, and vary from 3 meters to 5 meters in diameter. They are placed upon the engine shafts, and run at what we should regard as slow speed, the largest size being run 60 r. p. m. The potential is but 120 volts, and arc lights are run off at the same circuits of 1,800 candle power. Instead of using insulated cables, the conductors are simply copper bars, varying from 30 to 900 millimeters cross section. These bars are supported by glass insulators in cement tunnels, which are laid under the sidewalks. I expressed surprise that they should use such low voltage and so much copper, but the director of the company told me that it was altogether the best way, on account of its safety, and the great saving in losses by leakage. The Berlin Company laid 2,000 tons of copper last year, and will lay, the present year, about 3,000 tons; as I understand it about 80,000 tons will be required to completely light the city. I need not tell you that as a copper man, this was one of the most satisfactory visits that I made.

My time at Paris was limited to four days, most of which was absorbed by business interests. One full day, and three other flying visits to the Exposition gave me just an idea of its magnitude. The Eiffel tower and the Machinery Hall roof were the great engineering features. The Me-

chanical Exhibit disappointed me, and was not equal in quality to the Antwerp Exhibition of 1885, But other members of the Society, who had more time, will be better judges than myself of the Exposition as a whole.

By George H. Barrus.

I have been asked to give a narrative of what I saw during the Engineers' Excursion to Europe, having special reference to steam engineering. I hesitate somewhat to give my experience in this line, for the trip, on my part, was one devoted to pleasure and not to study, and I did not give sufficient attention to engineering subjects to speak of them in a way which will be of most value to engineers. I did not fail, however, to see many things in this line which are interesting, and some of these may be noticed.

During the outward voyage I passed a considerable amount of time in the engine room. This was a novelty to me, as well as to many who are less closely indentified with steam engineering, for it was my first experience on an ocean steamer at sea. Through some friends of the Inman Steamship Company, I had arranged with the chief engineer to take some indicator cards from the engine, and had come provided with indicators for this purpose. The engine was a vertical compound, running under 80 lbs. boiler pressure, and it was of a type somewhat antiquated; the steamer, "City of Richmond," being one of the oldest in the service. The indicators were applied to three-way cocks leading to the top and bottom of the cylinder, and one instrument was used for each. The indicator motion was derived from the lever which works the air pump, and the cords passed up or down, as the case might be, through the gratings which form the floors. There is no special difference in the manipulation of the indicator in itself on a marine engine, from that which occurs on an engine which is stationary. But the circumstances surrounding the work on board ship make it, on the whole, a very different process. The excessive rolling of the steamer, the great heat of the engine room, the untidy condition of all the iron work due to oil and dirt, and the unhandy location of the indicators, all combine to make the labor of obtaining cards quite difficult. I found that there was no pleasure in continuing the work any longer than to just get my hand broken in.

During my stay in the steam department of the ship I was struck by the difficulties under which the firemen perform their labors. The close quarters in which the boilers are placed, the absence of a great amount of light, the want of cleanliness, and above all, the excessively hot atmosphere, especially when the steamer was passing through the Gulf Stream, make their work exceedingly laborious. The heat could not be endured, it seems to me, even by sturdy firemen, if it were not for the relief afforded by moving back away from the boilers, and cooling off in the draught of air produced by ventilators.

A pleasant remembrance of my visit to Manchester, in England, was a call made on Mr. Lavington E. Fletcher, chief engineer of the Manchester Steam Users' Association. This association is engaged in similar work to that of the Boiler Insurance and Inspection Companies in our

country. They have a large museum in connection with their office, showing specimens of exploded boilers and injured boiler sheets, as also a large cabinet containing several thousand specimens of test pieces from boiler plates, which had been taken from boilers insured by the Company. In one part of this laboratory is a full-sized model of a Galloway boiler, arranged and set in the manner recommended by the Company. This boiler is the standard type of boiler in England, and I was surprised to learn from Mr. Fletcher that the horizontal return tubular boiler, which is so common in this country, was seldom used in theirs. He said they had found that externally fired boilers of this kind were troublesome on account of the bagging of the sheets exposed to the direct action of the fire, and for this reason they had refrained from their use. They seemed to be wedded to the Galloway boiler, and to be too conservative to bring into use the boiler which has given such well-merited satisfaction in this country.

In Manchester again, an interesting visit was made to the Engineering Laboratory of the Owens College, which is under the charge of Professor Osborne Reynolds. This laboratory is arranged partly for instruction in strength of materials, and partly for experimental work in steam engineering. For the latter purpose they have the best equipped engine, for instruction to engineering students, that I have seen. It is a triple-expansion engine, with vertical steam jacketed cylinders, and each cylinder is part of a complete engine, the three shafts being placed in line and provided with couplings, so that the whole can be run as a complete engine, or either one can be run independently. Each independent engine is provided with a brake, for the absorption of that part of the load which it drives, and this brake is a novelty, being of exceedingly small compass, and of great range, and handled with much ease. The principle is that of the turbine water wheel reversed. By subjecting the outgoing water to a sufficient pressure, a very small brake will suffice to absorb a large amount of power. There is no difficulty on account of heating, because the water carries off all the heat which is generated. Each cylinder is provided with indicators and suitable driving apparatus. The steam which passes through the cylinders is condensed in a surface condenser, and a complete equipment is provided for the conduct of scientific tests. The boiler is of the locomotive type, and I was informed that a horse-power had been produced for 1⅓ pounds of coal per hour.

A similar visit was made, in London, to Professor Unwin's Laboratory, at the City and Guilds of London Central Institution. Here was an extended line of apparatus for testing the strength of materials, and a steam engineering department, containing a complete equipment for instruction in steam engineering. The engine is a horizontal compound steam jacketed engine, and the fly-wheel is fitted with a Prony brake for absorbing and measuring the power. Tanks are provided for gauging the water supplied to the boiler, and injection water supplied to the surface condenser, and the whole apparatus is admirably suited to experimental work. This laboratory is fully described in the columns of *Engineering*.

An interesting trip was made to inspect the Willan's Engine Works at Thames Ditton. This engine is a triple-expansion high speed engine,

with vertical tandem cylinders. The piston rod is hollow, and serves as a passage for conducting the steam from one cylinder to another, and openings in the sides of the rod serve for ports. The engine is used for the various purposes for which high speed engines are employed in our country, and several were seen at the Sewage Disposal Works near by, engaged in driving centrifugal pumps. They obtain a high degree of economy with this type of engine, even when running non-condensing. Some experiments, which have been described in a paper read before the Institution of Civil Engineers, show that the engine, when running non-condensing, at 170 lbs. pressure and 400 revolutions per minute, and developing 40 indicated horse-power, used 18.4 lbs. of feed water per indicated horse-power per hour. Here, as at many other places where high speed engines, and other engines as well, are used, they employ indicators which are made in this country, and I am pleased to say that several leading engineers spoke in commendation of the writer's apparatus for determining the moisture in steam, also an American product.

The steam engineering exhibits in the Paris Exposition are full of opportunities for study. The boiler department is marked by a complete absence of shell boilers. The prevailing type is that of the water tube form. Engines of much size are largely fitted with Corliss valve gear, or with some form of four-valve gear, growing out of the Corliss type. The common method of attaching a condenser is to place it on the engine-room floor, with the air pump in front of, and in line with, the engine cylinder, and driven by a rod which is a continuation of the piston rod of the engine. There are many compound engines on exhibition in all departments.

I was much interested on one of the excursions in Paris, to find, attached to a factory engine, a system of cooling the hot water discharged from the condenser, so as to use the water over again and save the employment of fresh water. The engine was said to be of 75 horse-power. The apparatus for cooling the condenser water consisted of a staging placed in the yard, outside of the building, and elevated over a tank. The staging occupied a space of some 50 ft. in length, 10 feet in width and 35 ft. in height. It was divided into various compartments by means of horizontal open floors, and these were filled with small limbs of trees and brush. The water was pumped to the top of the staging, and distributed by means of troughs, so as to discharge upon the upper layer of brush, and from there it fell by gravity to the next layer below, and so on, gradually, until it reached the tank underneath. This arrangement enables the water to be broken up into fine particles, and to be brought into contact with the atmosphere and thereby cooled. From the tank it was carried to the condenser, and the process repeated. The same principle was carried out in an apparatus which was shown in the Exhibition, the staging being made of iron work, and the brush supplanted by perforated galvanized iron plates.

French Forestry Department.—By Fred. Brooks.

At the Paris Exposition the exhibition of the Department of "Eaux et

Forets" is made in a special building of its own. The exterior is covered with slabs showing the bark in such a way as to resemble tree trunks and has rustic decoration. This appropriateness of style is a minor illustration of the æsthetic taste which characterizes the French exhibition. Different portions of the interior of the Forestry Building are assigned each to a single kind of tree, and for each kind there is exhibited the surface with the bark on, sections transverse, radial and tangential, and the goods into which it is manufactured; as, for instance, one kind is made into wooden shoes, another into boxes, a third into bottle-stoppers, &c. This simplicity by which facts are made as clear as possible, even to untrained minds, is also very characteristic of the French exhibition; further illustration of it will be found in what I am going on to speak of. Another portion of the Forestry exhibition shows the work of the Department in the mountain regions, the French Alps and Pyrenees, in protecting the steeply sloping territory. Where a mountain side was liable to land slides or avalanches of rock, a series of retaining walls is built, and loose bowlders are supported, and the growth of vegetation is started to hold the soil. In valleys which torrents of water have occasionally devastated, some very extensive improvements are made. The injury by flood is not only the washing out of the upper valley, but the overwhelming of arable land in the flatter portion below with the detritus, destroying its fertility, and the cutting off of communication over government roads, which near the frontier are important from the military point of view. The cure for these evils is of the nature of substituting for the inclined bed of the stream a series of steps, so that, instead of acquiring such destructive velocity, the water may fall nearly dead from one pool to another. More practically speaking, the fundamental work of protection consists of building dams at short intervals on all the steep parts of the channels. These dams, however, are of several classes; in the upper and smaller channels they are merely little rough stone walls of the simplest character, while on the lower and larger portions of the streams some are fine masonry structures with waste-ways, comparable with the best that are built here for water power. It is not uncommon to put a hundred or more dams on a single stream. Besides, the beds of the steams are improved by removing their irregularities and establishing a smooth and approximately uniform cross section, so as to facilitate steadiness of flow. The banks, which may have been denuded, are re-planted with whatever is suitable to grow. This work of caring for the whole length of the channels has cost in the aggregate millions of francs; and to an American who is accustomed to seeing mountain streams left in a state of nature, it is very striking, and suggests that in this country it is high time that more general interest were awakened in the preservation of existing forests at least. The most conspicuous part of the exhibition consists of three handsome paintings, such as are called dioramas, giving very natural representations of three of the works as they would look to an actual spectator from a well-chosen point of view. They show mountain summits and landscape and possess merit as works of art. In one of the scenes the spectator seems to be looking out of a smithy; in another, out of an engineer's shanty fitted up in realistic style. In alcoves adjoining are collected maps on a large scale of the areas drained by the

streams, photographs for comparison taken from nearly the same standpoints before and after the execution of the works, and monographs describing the work in detail and giving its cost, also plans and sections, pictures of scenery and full information.

TERRESTRIAL GLOBE.

The visitor to the terrestrial globe goes first to the top of its building by staircase or elevator and then descends by a spiral walk, passing several times around the building, so that he can get a view of all the surface of the great globe. It is worthy of a visit, even from persons well acquainted with geography, for the realizing sense which it affords, better than is afforded by any other means, of the truth about our earth. The immensity of the Pacific Ocean, for instance, is less apparent to a person who sails upon it and can see but very little at a time, or who looks at a small globe and must see the continents shown around it, than it is to the visitor to the great globe who sees a considerable part of it at once and yet can see the ocean without any limiting land. This idea is set out in a different light in a supposed conversation between visitors which was printed in the humorous columns of one of the newspapers:

"Why, it seems to be all water!"

"Probably because it was cheaper to paint a uniform blue than to delineate the details of the land."

"What an extremely small spot France is!"

"Yes, that is a characteristic piece of modesty; she is unwilling to assume prominence," &c., &c.

The globe was prepared under the auspices of the leading geographers and scientific men, and the engineer of it was Mr. Seyrig, one of the French gentlemen who very kindly guided the American visiting engineers at the Exposition. The globe is 40 meters instead of 40 million meters in circumference, and therefore, 12.73 meters in diameter, so its linear dimensions are one millionth of natural size, or on a scale of 1 mm. to the km. No attempt is made to show varying altitudes by relief, for if truthfully done it would be imperceptible; the highest mountains rise less than 9,000 meters above the sea, and would, therefore, be represented by less than 9 millimeters elevation. Colors are used to show mountains, different depths of the sea, principal lines of communication, mineral deposits, &c. The surface is made up of 586 panels, bounded by lines of meridians and parallels of latitude, drawn and painted separately and attached to the metal framework or skeleton so that they can be taken apart again. The panels are of pasteboard with wooden frame within; a sample panel is exhibited so that the visitor may know just how the thing is made. The framework also can be taken apart. The panels weigh three tons, the framework ten tons. It is suspended on a pivot and turned around by gearing underneath. The rate of rotation, instead of being once a day, is rapid enough to let the spectator see the different meridians pass under view. Upon the walls of the building are a variety of statistics and appropriate information, and among other things a section on the same scale as the globe, showing the probable thickness of the earth's crust, of the atmosphere, the altitude of mountains and the depth of the sea.

CENTESIMAL DIVISION OF THE QUADRANT.

The meridians and parallels above referred to divide the quadrant decimally, and, correspondingly, the notation by grades, 400 of which make the circumference, is used on one of the wall diagrams above referred to, which calls for measure of arc. That division is engraved, along with the sexagesimal division into degrees, on the maps of the French military staff and of the detailed geological survey of France under the Ministry of Public Works. It is also used upon the graduation of mathematical instruments exhibited by the War Department, by the *Bureau des Longitudes*, and by eleven other exhibitors of scientific instruments, mostly upon tacheometers, but also upon theodolites, compasses and protractors. One instrument-maker told me the 400 grades were little used, except upon tacheometers, and that he had no 400-grade protractors in stock, but could make one if ordered. The tacheometer is essentially a theodolite with stadia hairs; it is used for determining distances as well as angles, and the name is Greek for "quick measurer." That there is nothing about the tacheometer necessitating its having decimal angular subdivision is shown by the fact that one was exhibited by the Algerian local administration which had the 360 degree subdivision. Another exhibitor, J. L. Sanguet, has just now published a new book of five-place centesimal trigonometric tables (Gauthier-Villars et Fils, Paris; 1889.) In his preface he says, in reference to the use of the centesimal division in tacheometry, that if not all observers have yet adopted it, it has been for the want of the same number and variety in trigonometric tables that they have with sexagesimal division. One of the French Civil Engineers' Reception Committee, of whom I inquired, made a similar statement. The preface also says that the centesimal division was proposed by Lagrange and introduced in pure mathematics and in the practice of astronomy and geodesy by Legendre, Lacroix, Carnot, Prony, Monge, Borda, Laplace, Mechain, Delambre, Puissant and others; and indorsed among our contemporaries by such eminent men as LeVerrier, Airy and Forster, directors respectively of the observatories of Paris, Greenwich and Berlin, by Gen. Perrier, Messrs. d'Abbadie, Houel, de Chancourtois and others; also that its use has been continued in the War Depot, and introduced into the instruction given at the School of Application of Artillery and Engineering, and that it has just now been adopted by the administration of the *Cadastre* or topographical survey of France; and that, all tacheometers having the centesimal graduation, its use has been carried into the applications of topography on public works; also that Delambre, after having used it on the Meridian Survey, said that no one who had had practice with both divisions would willingly return to the ancient; also that the centesimal division saves time in the ratio of three to two and risk of error in the ratio of four to one, in observation as well as in calculation.

One of our veteran engineers on this side of the Atlantic informs me that at the outset of his career, nearly fifty years ago, he used for a year a theodolite centesimally divided and found it convenient, and preferred it to the old style, and made tables adapted to it.

I think that it would be premature to agitate immediately in this country the adoption of the centesimal division of the quadrant. To secure

uniformity is of primary importance in matters of this kind, and one of the few things which we already have substantially uniform throughout the world is the division of the circle sexagesimally. Therefore, to maintain uniformity, we want to make sure of a uniform movement in changing, which I think will be much more feasible a little later than it is now. Our Committee on Weights and Measures in its report presented March 3, 1886, (and printed in THE JOURNAL OF THE ASSOCIATION OF ENGINEERING SOCIETIES, Vol. 5, p. 265, for May, 1886) gave considerable space to this subject, referring to the favorable action which was taken upon it at the International Conferences at Rome in 1883 and Washington in 1884. I was surprised to find that it had so much popularity in France, and am especially desirous to give this mention of it, because in a paper which I read before this Society April 17, 1878, entitled "Decimal and Other Arithmetical Notations," which was printed in *Van Nostrand's Eclectic Engineering Magazine* (see Vol. 12, p. 554, for June, 1878) I took it upon myself to say:

"If, simultaneously, in all civilized countries the technical and other schools of high grade should make a business of teaching the centesimal division to the rising generation as something which they would undoubtedly have to use in after life, no insuperable difficulty would be found in introducing it. It is comparatively a small class in the community that has to use circular measure, and that class is specially educated and intelligent enough to appreciate the force of arguments with regard to it. That at some future time concerted action among all nations will be perfectly feasible may be inferred from the continual increase of foreign intercourse which is now so conspicuous, and the multiplication of international exhibitions, associations and conventions, political, social, commercial and professional. The leaders of opinion will simply have to show, when the proper time comes, that it is worth while to adopt the centesimal division, and I believe it will eventually come into general use."

PROGRESS IN CIVIL AND MECHANICAL ENGINEERING AND ARCHITECTURE FOR 1889.

BY COMMITTEES OF THE CIVIL ENGINEERS' CLUB OF CLEVELAND.

[Read March 1, 1890.]

Report of Committee on Civil Engineering and Surveying.

BY CYRUS G. FORCE, JR., CHAIRMAN.

In the brief time allotted to-night to the Committee on Civil Engineering and Surveying, it would be impossible to note, even in outline, all

the prominent engineering works, the successful completion of which has marked the year past.

A brief description of the Forth Bridge, just now completed, and the Manchester Ship Canal in progress, have recently been given to the Club in a paper under the title "Civil Engineering in England," by one of our members, who joined the European excursion of the American Engineering Societies last summer; and a paper describing the Eiffel Tower is promised by another of our members, one of the visiting engineers. I will therefore pass these most noted recent engineering works in Europe, works which, on account of their great magnitude and unprecedented boldness of design have not failed to challenge our admiration as the most prominent monuments of engineering in the present century.

The new Croton Aqueduct is now practically completed; its actual construction was commenced in 1884. The work consists of about thirty miles of continuous underground conduit. The depth ranges from 32 feet to over 400 feet, being at an average of 170 feet below the surface, and leading from Croton Lake to One Hundred and Thirty-fifth Street, in New York City. In general alignment it is nearly straight, there being but a few slight deflections. There are a number of very substantial masonry gate-houses and blow-offs that seem to have been thoroughly considered in every particular. This is especially noticeable in the case of the new gate-house at Croton Lake.

Considered with reference to its hydraulics, this aqueduct may be divided into two parts: First, the horse-shoe section portions, acting as a flowing conduit, that is, not wholly filled with water, and, second, the circular section portions, under pressure. The first, and by far the greater part, extends from Croton Lake to a point a little south of the northerly limits of the city, having a uniform grade of .75 of a foot per mile, with the exception of a single break for a short distance at Gould's swamp; where, on account of soft material at a considerable depth, an inverted syphon was resorted to, passing under the swamp, the alignment remaining straight. The horizontal diameter of the flowing portion is 13.6 feet, and the height 13.5 feet, the bottom of the section being nearly flat.

The remaining portion of the conduit extending from near the city limits southerly to the gate house at 135th street, is circular in section and the area is less, the deep portion under the Harlem River being 10.5 feet in diameter, and the balance 12.25 feet in diameter in which the water will be under pressure. Provision is made for draining this deep section by pumping at Harlem River in case of necessary repairs. South of 135th street the water will be delivered to the reservoirs and to the distributing mains through large iron pipes.

Throughout almost its entire length, this conduit was excavated in gneiss rock, only a small portion being broken or loose to such an extent as to require timber bracing during construction; it was almost wholly excavated by tunnelling, and the material removed through vertical shafts, located on an average, one mile apart. The intention was that generally the headings should be pushed one half mile each way from the shafts, but in a number of cases other considerations varied this distance.

From the standpoint of to-day, no extraordinary difficulties in rock

tunnelling were overcome in the construction of this work, except in one or two cases, and then for short distances only. At the Harlem River depression a nearly vertical wedge shaped seam in the rock underlying the bed of the river and filled with soft mud was avoided by a considerable lowering of the grade line of the tunnel.

The work, in the main, was carried on quite uniformly, and with the aid of improved machinery, such as rock drills, air compressors, hoists and other appliances, necessary for such a great undertaking, and crowning all, the electric light. A general high rate of progress was attained. We are informed that in some of the best managed sections, a progress in excavation of from forty to fifty feet a week was made in driving one heading.

The tunnel is lined with brick throughout, mostly three rings thick, but in some of the deeper portions, four rings were used. The space outside the brick lining is designed to be filled solid with stone laid in cement mortar.

The estimated carrying capacity of the aqueduct is a little over 300,000,000 gallons of water in 24 hours, being a little over three times the capacity of the old aqueduct. Consequently the old and the new aqueducts combined are able to give New York City a daily supply of over 400,000,000 gallons of water.

Considering the length and diameter together, the new Croton Aqueduct is the largest tunnel work, for any purpose, ever constructed. There are other aqueducts, some of comparatively recent date, and others very old that are much longer than this one, but their cross-sections are insignificantly small in comparison, and they are mainly surface work. We are not certain that the actual cost to date of this great work has been given to the public, but it has been referred to roughly as costing $50,000,000.

Progress at the Hudson River tunnel has been slow. Recently the work has been undertaken by an English contractor, a Mr. Pierson, who has had a large experience on similar work. He is at present working, or preparing to work what is known as the Greathead Shield. The use of compressed air is continued, but in a somewhat different manner. Two air locks are used; the pressure in the foremost lock is 36 pounds, and supplies the air for the rear lock, in which the pressure is less.

This work is probably the most difficult of construction of any tunnel ever attempted. The material is soft silt, so soft that it will run if the air pressure is removed. At first as the air forces the water out of the newly exposed silt, it toughens the material, but after it is quite dry, it will not hang together and is again very troublesome to manage. A cast iron lining is at present being put in. Under the former management the "Anderson System" of tunnelling was used, and the tunnel lined with wrought iron plates reinforced with brick. At the St. Clair River tunnel a progress of about 15 feet per day at each heading is being made. Here the material is blue clay of varying degrees of stiffness. A shield, similar to that put in at the Hudson River tunnel is used. It is 21 feet in diameter, and 15 feet long, and is forced forward with 24 hydraulic jacks. The external friction is estimated at about 880 pounds per square foot. Quick-

sand seams and water are anticipated, and an air pressure plant is in position ready to be used when required. This tunnel is also lined with iron. The lining is made in cast segments, about 5 feet long, and 2.5 feet wide and 2 inches thick, with flanges on the sides and ends for bolting. Total length of the tunnel proper is about 6,000 feet. Approximately 4,000 feet remain to be built.

The construction of the new water works tunnel at Chicago has not progressed as steadily as the exceptionally good tunnelling material passed through in driving the other tunnels there, nor indeed, as the borings for this work gave the engineer good reason to expect. An awkward accident to the cylinders intended for the submerged inlet, also a large body of quicksand and water found at the shore shaft, and sand, gravel and water encountered at the headings under the lake, where good clay was confidently looked for, have led to a material change in the original plans for this work. The original plans provided for a tunnel of 8 feet internal diameter extending out under the lake a distance of about 4 miles, and ending at a submerged inlet of novel design. It is reported that from the point where the gravel and water were encountered, the 8 foot tunnel has been divided into two parallel tunnels, each 6 feet in diameter, lying about 50 feet apart; and that the submerged inlet project has been abandoned for a granite structure, resting upon concrete filled into the annular space, between two iron cylinders, and the concrete in turn resting upon a thick foundation platform, through which the permanent water inlets are made. The depth of water at the side of the inlet is 45 feet, and the bottom of the lake is hard pan.

The tunnel is at present carried on at six headings, two from the shore shaft and two either side of a shaft at the government break-water. No tunnelling has yet been done as originally contemplated, from a temporary crib and shaft near the center of the tunnel, owing to delays in getting the crib into proper position.

Some progress has been made in the construction of the canal and tunnel designed for the drainage of the City of Mexico, and of the oval shaped basin from 25 to 35 miles wide and from 50 to 60 miles long, at the southerly end of which the city stands.

The project consists in excavating an open canal, the bottom of which, throughout its upper portion, is 10 feet wide with sides sloping at 45 degrees, from the City of Mexico, along Lake Texcuco, a shallow salt water lake situated at the lowest part of the basin into which the drainage of the City of Mexico naturally flows, thence northerly through several small lakes, the water of which is brackish, into the northerly watershed of the basin, to a point where the cutting becomes about 85 feet deep. From this point, a tunnel 19 feet in diameter in the clear, after being lined mainly with brick, and about 6 miles long, is being driven through hills which rise about 200 feet above the average level of the basin, and beyond which is a natural drainage to the ocean.

The material to be excavated for both the canal and tunnel, is a volcanic rock called Tepetata and is similar in hardness to our local shale, but homogeneous. It is now being excavated in the canal by dredging and in the tunnel by the use of the pick and shovel. The evaporation at the

City of Mexico is very rapid, which accounts for the disposal of a large portion of the rain-fall in this at present water-locked basin.

The actual construction of this work was commenced by the Mexicans themselves, a number of years ago, but no great progress was made until recently, when portions of the canal excavation and tunnel work have been let to American and European contractors. An approximate estimate of its cost is now put at $7,500,000 Mexican money.

The general progress in bridge engineering, in this country has shown a constant, and for the most part, a steady growth. This is noticable in increasing span lengths, (a quite popular way just now of comparing bridges) and in the gradual development of the most favorable type for the great majority of cases: also in the design of special bridges for special and extraordinary cases, and particularly in improved forms and better proportions of compression members and all the details of bridge work.

So nearly have the patent bridges and all personal hobbies in bridges been eliminated from our late bridge designs everywhere in this country, and so generally has the trapezoidal, pin-connected, independent truss with equal panels, open compression members and machine fitted joints, become the standard design for the thousand and one cases that occur, that bridges with these leading features are now recognized and referred to by engineers and others in all countries, as the "American Type."

There are in this country a few special bridges which, on account of the exceptionally high grade of shop work on them, and the care and scientific investigation had in selecting, making and testing the materials used in their construction, and other bridges, which on account of some excellent feature in their general design for special cases not before fully appreciated, have distinctly marked an advance in bridge engineering.

The St. Louis bridge, all will agree, is a notable example of the first, and an example of the second class is not wanting. When the Kentucky River Cantilever bridge was completed, the first of its kind of any considerable magnitude in this country, attention was drawn to the possibilities and advantages of this design for locations where unusually long spans are a necessity and where the difficulties in erection had hitherto limited the designs mainly to suspension bridges.

Following this bridge there are at this date, in this country, no less than eight Cantilever bridges, completed or in progress of construction; some with a single opening over wide and deep cataracts, as at Niagara Falls; others consisting of a series of cantilever and anchorage spans, crossing broad deep rivers with beds of soft shifting mud and silt, 100 feet or more in depth as at Poughkeepsie and Memphis.

The necessity for durable swing bridges (and a swing bridge is a machine as well as a bridge) has led to a decided progress of late in the design and execution of this class of work. Especially is this the case in regard to the turntable and its appliances, the machine part of the bridge. The cost of maintainance and operating being among the controlling features in the designs. Most of the modern swing bridges in cities are now operated by steam power at about the same cost as that of operating by hand the former, lighter bridges at the same site.

For a long time the swing bridge, 474 feet long, over the mouth of the

Raritan River stood at the head of its class as to length. Within the past year or two, however, two such bridges, each about 500 feet in length, have been put in operation; one over the Thames River at New London, Conn., and the other over Staten Island Sound at the Kills.

The progress made in bridge engineering is not due solely to the theoretical investigations and practical skill displayed in the preparation of bridge designs. The demands of the civil engineers for high grade work in bridge shops and for rigid tests of materials both in specimens and full sized members have been responded to by their brethren, the mechanical engineers, by supplying the straightening machine, the rotary planing machine, the power riveter, the die-forge hammer, the upsetting machine with its product of weldless eye bars, and testing machines of great power and accuracy, chief among the latter being the noted Emery machine, capable of testing full size bridge members with a stress of 750,000 pounds in compression, and 1,000,000 pounds in tension, and at the same time so sensitive that the tensile strength of a single horse hair can be accurately measured with it.

DISCUSSION.

COL. W. H. PAINE: "Work at Hoboken River Tunnel, which has been progressing for fourteen years slowly, has now reached a distance of 2,050 ft. from the Jersey City side and about 500 ft. on the New York side. Parties who are now taking hold of it are backed by considerable means as I understand, and it will no doubt now be pushed to completion.

Work at the Port Sarnia tunnel is being pushed very rapidly, and 15 ft. per day has been accomplished. The distance yet to be tunneled under St. Clair River is about 6,000 ft.

The size of the tunnel at Sarnia is 21 ft. The exterior of the lining of tunnel is 20 ft. 6 inches; flanges are 7 inches; the material is 2 inches thick.

Referring to work at Hoboken, the trouble is, if air pressure is increased the tunnel will immediately fill with soft mud. If the pressure is decreased it will immediately make an opening in the river, so they are running along with little safety, and yet work 5 to 6 ft. per day."

Report of Committee on Mechanical Engineering.

BY WALTER MILLER, CHAIRMAN.

In behalf of the Chairman of the Committee on Mechanical Engineering, the writer has been requested to review the progress made in mechanical engineering during the past year in the city of Cleveland.

We will first call your attention to the progress made in street railways

in this city. The past year has seen some very marked changes in the manner of operating some of these lines, and before the close of another year, we are promised still further developments. The permanent way has been very much improved; rails of more correct section and of heavier pattern have been laid down, as the advent of the electric motor demanded. While the electric system as a motive power does not seem to fill all the requirements for a good, safe and rapid transit, it is a vast improvement over that of the horse cars, and the public would protest against its removal. This system has been very much improved since it was first introduced in this city, and further improvements will be developed as experience may suggest. The members who had the pleasure of listening to a paper read before this Club on electricity as a motive power will remember the interesting discussion that followed.

The advocates of the cable system are putting down a plant in Cleveland, and promise to have it in running order within the next six or eight months, and if one were to judge from the substantial manner of laying the permanent way and the talent and experience that is being brought to bear on the design of cable driving gear, the enterprise will be a success from the start. The success with which this system is being operated in other cities should convince the public that this is one of the most desirable methods of rapid transit.

There has been a vast improvement in the traffic of coal and ore to and from the port of Cleveland in the past year, and to be able to handle this immense business with cheapness and despatch, so that our sister cities might not claim it all, decided improvement had to be made in the manner of operating. We may say that this has been accomplished, or will be, when the entire system is completed. With this improved method of elevating and conveying in full operation, Cleveland will be second to no other city on Lake Erie.

The public has very little idea of the extent of the ship-building going on in the yards at this port. The coming year will see 90,000 tons of steel, iron and wooden shipping put afloat on the great lakes and fully one-half of this tonnage will be put out at the Cleveland yards. The most marked change brought out in this industry is the introduction of steel decks and double butt straps on sheer strakes and deck stringers, and steel spars, although there is a strong tendency to reduce the number of spars used in each vessel.

In the matter of triple expansion engines for lake service, it may be said that they have come to stay, and the past year has developed improvements affecting their economy of fuel. Compounds for land service are being inquired for by parties where economy of fuel is an important consideration, and it will be remembered that the Club listened to a very interesting paper a short time ago on the compound steam turbine.

The forging of shafts, cranks, stem, stern posts and rudder frames required for this inland ship-building and engine work, as well as for those on the coast, and the large forgings of every description used in engineering work throughout the country have been the means of building up in this city an immense industry which has become one of the largest in the United States. The largest forgings turned out by this establishment the

past year were made for the new steamer "Plymouth," on Long Island Sound. One of the paddle wheel shafts is 27 inches in diameter by 35 ft. long and weighed, when finished, 30 tons. All of the connecting rods, links, etc., used on the engine for this steamer were finished at these works, complete, except the brasses. The largest forging yet turned out by this concern weighed 44 tons.

The flanging and riveting of the heavy boilers used for lake service that was formerly done by hand and steam is now almost entirely done by hydraulic power, both by stationary and portable machines. Forced draft has been tried in one case on a lake steamer but was not a success.

There are a number of other interesting mechanical enterprises which have been developed during the past year, but more time would be required for their description than is available on the present occasion.

Report of Committee on Architecture.

BY JOHN H. RICHARDSON, CHAIRMAN.

The progress of architecture, like progress in any other line, must for the short space of one year be necessarily slight.

The art *moves*, however, enough to be appreciated even in that time and moves as other bodies do in the line of least resistance or, commercially speaking, according to the law of supply and demand; the problem presented to the architect for solution being those suggested by the wants or sentiments of the community.

The structures of by-gone ages, which have survived, and now remain as monuments of the art, are mainly ecclesiastical—cathedrals and temples of worship.

It has been generally considered that *great* buildings of that character were things of the past, that the conditions which led to their development and made them possible no longer exist. That the equally great buildings of the future (should we ever have any) would be in the line of government buildings and institutions of learning, literature and art.

The past year, however, has witnessed the inception of a fine cathedral for the diocese of New York, the project receiving quite an enthusiastic support. Should like sentiments continue and grow, our structures of that nature may yet rival Cologne, Strasburg, and even St. Peter's itself.

Among buildings devoted to amusements, we note the fine Auditorium of Chicago, which has just been completed, but only to be eclipsed by a still greater which is now rising from the ruins of the Madison Square Garden of New York, and intended to be the largest, if not the costliest temple of amusement in the world, with an amphitheatre capable of containing 12,000 people. A theatre with a seating capacity of 1,500, a concert hall of the same capacity, a restaurant to equal Delmonico's, and a roof garden of corresponding proportions.

The equipments and decorations are to be simply magnificent and are

intended to eclipse anything heretofore seen in this country.

Such rivalry in this direction may soon render a visit to the Coliseum of Rome a useless pilgrimage, as we may find the real article on our own shores in full operation accompanied by all modern improvements including possibly a base ball field for winter sport.

In the business department we find the modern office building progressing steadily upward. The latest, the new Pulitzer building, of New York, being called the highest business structure in the world, but Chicago with her 16 story Monadnock buildingk eeping up in the race. Minneapolis, however, bids fair to outdo both Chicago and New York. A recent design from that region of grist-mills, shows an office building of 28 stories in height, the author of said design claiming a new method of construction by which the height of such buildings may rival that of the Eiffel Tower.

Further progress in this line of *Eiffelism* may soon give us some tangible illustrations of the legends of Babel.

In domestic architecture the movement is not upward, low stories being still the rule; comfort, convenience and real enjoyment (rather than display) being the end sought. The general development of rapid transit facilities is changing the current of feeling in favor of suburban residences, rather than down town flats.

The monumental spirit is abroad in the land, many notable examples having been either commenced or projected during the past year, the latest mentioned being the Washington Centennial arch, at Washington Square, New York, estimated to cost not less than $150.000, a goodly proportion of which has already been subscribed.

The premiums for the Grant monument have recently been awarded to the successful competitors. A second competition will likely be announced. The sum of $140,000 has already been subscribed.

Castles in the air are not yet things of the past, as some have appeared during the by-gone years. One, a crystal palace for the World's Fair in New York (had she only got that much coveted prize.) This was to be built on a platform of steel, having an area of 60 square acres. and carried above the roofs of the houses on long pillars. the superstructure being of iron and glass. The proposition was made to the World's Fair committee by an architect and an engineer who had laid their heads together with this result. The other was a crystal tower of plate glass 1,200 feet high—also for the World's Fair. Palaces on the water have also been considered, the feasibility of a floating theatre and floating museum having been duly presented to the investing public.

Among building materials structural iron and steel are gradually taking the place of heavy timbers and allowance for shrinkage will soon give place to provisions for contraction and expansion, and the dread of dry rot to the fear of corrosion.

The year has added its quota to the burdens of the architect, the complexity of modern buildings, of whatever character, being steadily on the increase. New problems in heating, sanitary requirements, mechanical and electrical appliances, requiring additional thought and study, the most difficult study of all being to bring the aggregated total within the limits of the intended cost.

ASSOCIATION OF ENGINEERING SOCIETIES.

PROCEEDINGS.

WESTERN SOCIETY OF ENGINEERS.

ANNUAL MEETING.—The annual meeting, 265th of the Society, was held at Kinsley's, at 7:30 p. m., January 8th. The Secretary called the meeting to order and in the unavoidable absence of President Corthell, Gen. Chas. FitzSimons occupied the chair.

The reading of the minutes of the previous meeting was dispensed with, and Messrs. John Lundie and W. R. Northway were appointed tellers to canvass the vote for officers for the year 1890.

Upon reports of officers being called for, the Secretary submitted the following:

ANNUAL REPORT OF SECRETARY FOR 1889.

The present membership of the Society is 255, exclusive of resignations now to take effect. During the past year 84 names have been added to our list. The resignations number 15, the same as last year, and we have lost three members by death. The increase of 84 in our membership list is, as far as I am aware, the largest that ever occurred in one year in the history of the Society. I would say, however, that it includes a small percentage of old members, who have rejoined.

The resignations include several members who have been engaged for railroad work in South America.

The total receipts from all sources have been $2501.46, and some $450 remain to be collected. This is due to no special efforts having been made to collect closely in December; consequently bills to the amount of about $200 await payment.

From the above figures it may be confidently stated that notwithstanding the broader and more expensive work of the Society during 1889, the receipts practically cover the expenses.

In pursuance of the policy inaugurated during the term of my predecessor, Mr. Cooley, the Society undertook to move into its present commodious quarters in April last. The policy of which this change of quarters was one of the contingencies, seems to have resulted in greater professional activity of the Society, the largest attendance at its meetings ever known, and the prospects of continued and enlarged prosperity. The condition of the Society to-day already makes it probable that much larger quarters will be necessary at a comparatively early date. Since May last the average attendance has exceeded forty members and guests, and at one meeting the attendance virtually taxed the capacity of the quarters. It seems to follow that a permanent and commodious home must be an early consideration of the Society.

The work of the Society for the early months of the year consisted mainly in discussing matters pertaining to changes in the conduct of business and an entire revision of its Constitution and By-laws.

The Committee on Highway Bridges made a report and asked to be discharged, which was so ordered. The Committee on Employment has made verbal reports at intervals and has been continued.

The Committee on Standard Drawing Papers for Engineers reported in March. A paper on "The Croton Valley Storage," by Mr. Samuel McElroy was also presented.

In May last the house-warming in the new rooms took place, and pertinent discussions on the general condition and prospects of the Society was a feature of the occasion. This resulted in active work of the Board of Directors and an entire change of method in carrying out the policy so long advised. The actual results are before the Society.

Papers have also been read: By Mr. Guthrie, "On the Chicago Drainage Problem;" by Mr. Cope Whitehouse, "On the Raijan Reservoir;" by Mr. Liljencrantz, "On Compound Lumber," and by Mr. Gregg, "On Power Transmission by Manila Ropes." Active discussions followed these several papers, which were taken stenographically.

The Secretary regrets to record the deaths of three members—Robert G. Turknett, Ed. B. Meatyard and D. J. Miller.

The monthly reports of the Society have been printed very fully, a matter of considerable value to non-resident members.

FINANCIAL STATEMENT.

RECEIPTS.

Cash, Balance from retiring Treasurer	$ 163.97	
" Fees and dues from Members	2,297.49	
" Supper Fund	40.00	
Total receipts		$2,501.46

DISBURSEMENTS.

Journal of Engineering	$769.25	
Secretary's salary	741.38	
Rent of rooms	444.00	
Printing	204.75	
Stationary and Stamps	155.11	
Sundries	70.00	
Moving expenses	37.50	
Sundries in furniture and office supplies, etc	36.47	
Stenographer	29.00	
Gas	6.00	
Total disbursements		$2,501.46

It was voted that the financial report be referred to the Board of Directors.

The Secretary, in presenting the resignation of Mr. Liljencrantz as Librarian, referred to the omission of the Society, on the occasion of its first meeting in its new quarters, in not acknowledging the great services of Mr. Liljencrantz in the work of moving and settling, while other committees had been duly thanked.

Mr. L. E. Cooley briefly reviewed Mr. Liljencrantz's work for the Society, and moved, "That the Executive Board be authorized to make such a record as will set forth the facts in the premises and spread it upon the records of the Society." The motion was seconded and unanimously carried.

The Secretary then read a telegram and letter from Mr. Corthell, and the following remarks from him as President of the Society:

"It is a satisfaction to know from the report of your Secretary that the Western Society of Engineers, whose headquarters are in this city, is not in a moribund condition, but in one of active growth, for his report shows that the increase in membership during the last year has been 40 per cent. of the entire membership at the beginning of the year, and it is safe to say that this membership is an active one; that there is no dead wood in it; that the men who have joined this Society during the last year have done it with a purpose and that purpose has been two-fold, no doubt: First, to promote the general interests of engineering in this city and in the country tributary to it; and, second, to promote their own individual growth and usefulness as engineers. This Society has arrived at that point where there should be only active membership, and where everyone should take hold in earnest to make the Society with its meritorious objects an eminent success and of great usefulness in the important sections of the country where it is placed. We certainly have arrived at that point where the Society rooms should be ample to accommodate all who wish to come day or evening, and where there should be upon our reading tables all of the leading engineering literature of the day, and where, upon shelves, should be all of the standard works; and further, we have arrived at that point where it appears to be absolutely necessary that the Secretary, who is the executive officer of the Society, and must be depended upon to attend to its wants, to obtain new members and to further its interests in every possible way, should be able to give most of his time, at any rate, to our work. To do this we must compensate him for his labors and for the time it is necessary for him to give to our interests. During the rapid growth, which evidently is still before us, it might be good policy to make the amount of his salary dependent somewhat on the per cent. of increase year by year; that is, for illustration, we might pay $1,200 if the Society remains in membership simply as it now is, or $1,500 if the increase during the year is 20 per cent., or $1,800 if 40 per cent., and so on giving the Secretary an inducement to devote himself to the acquisition of members as well as to the regular duties of his business in attending to the routine of the Society. This is a suggestion only for your consideration."

It was voted, on motion of Mr. George W. Waite, that the business suggestions of the President be referred to the Board of Directors with power to act.

The tellers reported the following canvass of letter ballots for the officers for 1890: For President, 112 votes cast: Mr. L. E. Cooley, 63; Mr. O. Chanute, 49. For 1st Vice-President, 108 votes cast: Mr. Robert A. Shailer, 59; Mr. Robert Forsyth, 49. For 2nd Vice-President, 108 votes cast: Mr. W. R. Northway, 64; Mr. J. F. Wallace, 44. For Secretary, Treasurer and Librarian, 112 votes cast: Mr. John W. Weston. For Trustee, 102 votes cast: Mr. Benezette Williams, 61; Mr. A. Gottlieb, 41.

The Chairman announced that Mr. L. E. Cooley was elected President; Mr.

Robert A. Shailer, 1st Vice-President; Mr. W. R. Northway, 2nd Vice-President; Mr. John W. Weston, Secretary, Treasurer and Librarian; Mr. Benezette Williams, Trustee.

The Chairman announced that President Corthell's address was next on the programme, which was read by the Secretary.

The continuation of Mr. Corthell's paper consisted of descriptions of the following engineering works, illustrated by some 80 stereopticon views:

Liverpool Docks; Menai Suspension Bridge; Britannia Bridge; The Garabit Viaduct; Sault Ste. Marie Canal; Manchester Ship Canal, Panama Canal Locks; St. Louis Bridge; The New York and Brooklyn Bridge; Sioux City Bridge; Cairo Bridge; Ohio River Bridge at Cincinnati; Thames River Bridge; Hawkesbury Bridge; The Forth Bridge; St. Louis Merchants' Bridge; Memphis Bridge; The Eiffel Tower; The Mississippi Jetties; Chignecto Marine Railway; Tehuantepec Ship Railway; New Orleans Bridge; Detroit River Bridge, and the North River Bridge.

When the lights were again turned up Mr. C. L. Strobel, in remarking upon the valuable paper just given, drew attention to the fact that a large amount of the labor of presenting the matter had fallen upon Mr. Wm. J. Karner, Mr. Corthell's Secretary, and that it should be in order to recognise his exertions in some way, and he would move that a vote of thanks be tendered Mr. Karner. A vote of thanks was also given to Mr. Corthell for his valuable paper.

Before inducting the newly elected president, Mr. L. E. Cooley to the chair, luncheon was served and a very pleasant social time enjoyed.

In due course General FitzSimons again called the meeting to order and appointed a committee, Mr. O. Chanute and Mr. W. R. Northway, to escort Mr. Cooley to the chair.

President Cooley in thanking the Society, suggested that as it was customary for the retiring president to make the annual speech he would beg leave to be allowed to follow that rule. As engineers were not accustomed to talk until an example had been set, he would ask Judge Prendergast to address the Society.

Judge Prendergast spoke as follows:

MR. PRESIDENT:—I esteem it, gentlemen, as more than an ordinary pleasure to offer my congratulations to your splendid profession, that the prophesy, made at your banquet table three year ago,—which then seemed far from likely of fulfillment,—has been already fulfilled, thanks to the gentleman,—and to him more than any man that I know,—whom you have called to be your president to-night.

I was accorded the privilege, three years ago, of speaking to your Society upon the subject of a great waterway, connecting Lake Michigan with the Mississippi River. There were so few laymen at that time who appreciated the importance and feasibility of that project, not only to Chicago, in her local needs of sanitation, in the purification of her water supply, but to Chicago as a commercial centre, and to the country of which she is the predestined commercial centre, that I sometimes would have blushed, if such a thing were possible in my profession, at the idea so frequently at that time thrown out, that I was a waterway crank. But you see, an old phrase of somewhat remote antiquity is that "The mills of the gods grind slowly," and in this case, the crank has gone around, and to day the people of this country have before them the prospect that upon this continent will be realized a work of engineering that will surpass, so far as I have been able to learn, anything that history shows forth.

We have, in other lands, where the human race has achieved great heights, and accomplished great things in the past, splendid monuments of man's greatness and his power. We have aqueducts in Italy, Roman Walls wherever the Eagles of the Cæsars were victorious, walls surrounding and encircling the great empires of the East; Egypt was filled with monuments, but all these things are tending towards decay.

What we propose to do here will not be a monument in the sense of monumental ruin. Time will forever see the perpetual springs that made the Great Lakes the source of that inexhaustible supply which will make this great waterway a living monument, a moving monument, a thing of life forever. And this work is only possible because of the human thought and study and effort that have been devoted, by men of your profession, to the accomplishment of such works.

I am sure that I would esteem it a privilege to be a member of a Society with a president whose name will be linked, even if he does nothing further than he has done, imperishably and inseparably with this project for all time.

It is the habit, or rather not the habit, it is the accident of men unacquainted with the grandeur of this project, to look only at one of its features and uses. We hear a great deal about this being a drainage channel—an enlarged sewer for Chicago. Why the people of this city would be what they have never yet been—they would be recreant to their word if they would embark upon the construction merely of a sewer. They are committed, irrevocably, to the making of a great waterway,

having for its local justification, the justification for the raising of taxes, the truth that the Chicago sewerage system will be bettered, and that her water supply will be rendered free from pollution for all time.

But in order to procure the legislation, the authority necessary to accomplish that purpose, Chicago pledged herself—and in the law is written her pledge—and even though there were those base nough , whom I think do not exist here, to de-desire it otherwise, the law will not permit anything else than that a great navigable waterway will be constructed between Chicago and Joliet, on the expectation that the United States government, without departing from the policy it has adopted of making no artificial channels, will take hold of the natural channels of the Illinois river, and the Mississippi, and improve them so as to be fit, and adequate and commensurate constituents of the great navigable waterway that Chicago and Illinois are pledged to construct.

I owe very much of my interest in this subject to the companionship and association with your president, and with other members of your Society, and if recent events are any indication, the people seem to think that I have a very good tutor. If the scholar has been called to the head of the class, the master must get the credit.

This enterprise, in its present state, is one of great satisfaction. A matter of so much moment, before it can finally be put upon the incline of motion, is to be examined carefully. It has reached that stage where the law and the lawyers will endeavor, for one reason and another, to get their crowbars in, and wrench out some of the stones, and it behooves all who have duties to perform at the present moment, in connection with the subject, to be faithful—to be careful—to take no step in the arena of litigation that will not be prudent and discreet; but because that is true is no reason and gives no proof to those rumors that we see in print that there is anything like uncertainty, or a hitch in the proceedings. At the present moment there is under discussion this question, and this alone: Which is the best mode of testing the constitutionality of this law? That is all. A question of so much importance, to be dealt with by at least eight minds, not all of them entirely familiar either with the project itself, or with its legal relations, justifies a pause. Within a few days I think the mode of procedure will be settled: will be drawn up: will be adopted. You, I think, are entitled to know just what those proceedings outlined are.

It is suggested, on the one hand, that the better method is for this Board of Trustees to organize, and that when organized and attempting to proceed to the discharge of their duties, some litigation will be instituted, either in the nature of a bill in chancery, or a writ of *quo warranto*, or some other procedure, whereby the legality and constitutionality of the Board's existence may be inquired into and determined by the tribunal of last resort—the Supreme Court of this State. It is suggested in connection with that line of action, that once the Board is organized and attempts to proceed in the discharge of its duties, it will be open to the attacks of all citizens; those friendly and those unfriendly to the project, and no one knows better than members of this Society who were present, as were my friend, Mr. Gottlieb, Mr. Cooley, and possibly others, at the Peoria convention, the Manufacturers' convention, and at the session of the Legislature a year ago, that this project has enemies—powerful ones. That is, powerful if we are to judge by a willingness to spend money. I have yet to learn that those who have a great deal of money spend any of it for fun. It is only the poor that are willing to get rid of that which they have not got.

Gentlemen have attended—I would not call them lobbyists—they have attended the sessions of the Legislature and the various popular gatherings, to speak in opposition to this waterway project. I failed to discover—on the surface, at least—their constituency, but that they had a constituency, goes without much argument. Now, if the Board organizes, this constituency may be active again with litigation. To meet that state of affairs, another mode of procedure is suggested of testing this law. That is a mode of *mandamus* proceedings to compel the issuance of certificates of election. There is not the slightest desire on the part of the officials to withhold them for the purpose of obstruction. They will not withhold them at all if a majority of the Trustees elect request that they be issued, and decide against the *mandamus* proceedings. It will depend entirely, I think, upon the desire of the Trustees, because to those men—to those individuals—the people have committed the great trust of accomplishin g this purpose, and of course all the proprieties demand that with them, will rest the decision, and ought to rest the decision as to the mode to be adopted.

The special advantage offered in connection with *mandamus* proceedings is this: That officers selected according to law, and acting under sworn obligations, will be the respondents. Men who have no official or personal interest in throwing obstacles in the way of the speedy decision will be defendants in the suit, and the plaintiffs will be the trustees elect, who, I will guarantee, every one of them, wants no delay, but wants to get at this thing if for no other purpose, the purpose of holding office. Of course, except the present member of board, all the others are free from a desire to hold office, but I will say that the motive is strong enough, the desire to serve the people, but to some men, if I can trust what I have heard, it is inexpressibly sweet to serve the people in an official capacity.

However, whatever mode is to be adopted will be determined in a few days.

If I could anticipate, if I could assume the robes of prophecy, as I did a few years ago, when I said that this project would certainly materialize, that Fate had so ordained it, that here, upon the lowest point of the divide between the valleys of the Mississippi and the St. Lawrence, where nature turned the waters of the Great Lakes southward, and cut the great wide valley of the Illinois, that here, upon this spot, Destiny, Fate, God, had pointed his finger, and said, "There shall be the great commercial centre, all modes of travel converge there." Man, following in the

lines that nature's God has mapped out, has already begun to realize the splendid opportunity that has been offered here for commercial greatness, and there must be a waterway. The water mode of communication, the exchange of commerce, is the immemorial mode. It is that which made the cities of the Ancient World great, and it is that which will regulate the railways, and the railroad tariffs without interfering with the value of railroads, but on the contrary, increasing their efficiency, their profit to their owners, and increasing their profit to their higher owners, the people; because, over all, the people own the railroads. It is they who pay the money, and in the course of a few years, the original investment, put in by the original adventurers, is repaid, so that to your Society, to the gentlemen of your profession, we must now look, after the lawyers brush away the little temporary obstructions of a legal character that exist, to you, the people must look for light, for guidance, for instruction. Upon the knowledge that is concentrated in your profession must be built this great structure, this greatest of the century, in my opinion,, and it affords me, as I can never cease saying, much gratification, on two occasions to have been able to be present at a meeting of this Society, once when I told what Mr. Cooley had done in the past, what he was going to do, and to-night, when I come, and unexpectedly witness the honor that you gentlemen have conferred upon him. The highest honor, I believe, that can be conferred upon a member of a learned profession is to be called to the highest office in the gift of its special Society.

I thank you sincerely for your attention.

The president next called upon Mr. Richard Morgan, of Dwight, Ill., who said:

I certainly must say, Mr. President, that this is unexpected. This is the first time I have ever had the pleasure of visiting this Society, although I have been a member of it for some years. I have been deeply impressed to-night by what has been said, and by the illustrations that have been given. Of course it is too late to enter upon an engineering subject to-night, and therefore I shall content myself with an episode in practical engineering which came under my observation a great many years ago.

First of all, however, I will speak of the wonderful statistics that your retiring president has presented to this Society. The movement of persons and property which he has given, and the very short period of time in which the great change has taken place in this country.

In 1843, there was a very enthusiastic railway meeting in Poughkeepsie, on the Hudson river, attended by such men as Matthew Vassar, and that class of men, and for the purpose of making a preliminary survey of the Hudson River Railroad. At that meeting the gentlemen came forward in the most liberal manner, and the sum of money raised was $75.50. Marking the contrast between that period in railway work and the statements made by your retiring president, I think of the advance that has been made. The episode of practical engineering that I referred to goes back to the primary part, in the survey of the Hudson river road, at a point north of Poughkeepsie about three miles—Stuyvesant's Point it was called. The great grandson of Peter the Headstrong resided there, and it was called Stuyvesant's Point. A party of engineers were engaged in the survey of that very point in the river, and in that party was a slight young gentleman, who was carrying the hind end of the chain, and at that point, it was extremely difficult. The man who had hold of the forward end of the chain was a tall, lank Yankee, and the position was so difficult that it was impossible for him to turn around. The young gentleman who was attending to the hind end of the chain slipped and fell from the precipice into the river, which was filled with ice. The man dragging the forward end of the chain, without turning around, sung out, "Man overboard," and sure enough this young gentleman had fallen from the precipice and into the river, and was very much injured. We succeeded in getting him out, took him up to the grand-son's residence—the grand-son of Peter the Headstrong, who was a man who weighed about 300 pounds, while our young gentleman weighed a little over 100. We got a suit of his clothes and put on this young man and they went around him twice and buttoned in the back, and in that condition he was transported to Poughkeepsie. The next morning work was commenced in the same locality, and the same Yankee was drawing the chain. I will mention the name, Mr. Jas. C. Spencer, the present President of the Milwaukee Northern Road, was running the party, and in a pretty imperative manner he said to the man drawing the chain: "Why don't you hurry up?" The man very quietly put the handle of the chain on a projecting stone and turned around, and looking at Mr. Spencer, said: "Mr. Spencer, if you think I am going to break my neck for nine shillings a day, you are sucked in." The young gentleman that rolled into the river and was so seriously injured, was so enthusiastic in the profession he had adopted that he was neither cooled by the river, nor by the fall was he prevented from pursuing his profession, and he has pursued it continuously since that time. He has been an engineer of great success, and he is now with us to-night. I have not met with him for a number of years. I have reference to Mr. Chanute.

There are two morals in what I have said that some of the young engineers present may take note of. The first is: Don't break your necks for nine shillings a day; and the second is, when you start to be an engineer don't give up the ship if you fall overboard.

It now being quite late and the wish of the majority seeming to be in favor of adjournment, Mr. Cooley suggested that before so doing, the Society would be very glad to hear from Mr. Chanute. Mr. Chanute said:

I am happy to say that, notwithstanding the occurrence which Mr. Morgan has

referred to, and which happened, I believe, some forty-one years ago, I am still alive and have the pleasure of addressing you to-night.

Upon returning from Europe about a week ago I found, most unexpectedly, that I had been nominated, in my absence, and without my consent, as one of the candidates for the Presidency of your Society. I deem it a high honor, and I thank the gentlemen of the Society for having conferred it upon me, while I wish to congratulate them upon having made a much better choice, and having elected to-night, as their President, a man whom I feel sure, will do very much toward improving the Society's affairs, and raising to a still higher plane the position that engineers take in this country, which, in my judgment, is as yet inferior to the position they hold abroad, and the position which I feel sure they will attain in the future.

One of the pleasantest features of the trip of the American engineers to Europe was in observing the respect, the honor with which engineers are treated abroad. Not only do they receive very much better compensation than in this country, but they are looked upon as at the head of the industrial movements, and without whose assistance no great scheme can be carried out. Among the first visits which we paid while in London was one to Westminster Abbey, and there we found monuments to engineers by the side of the great warriors and statesmen that that country has produced. In the picture galleries the pictures of engineers were hanging upon the walls. We find long aisles in the Crystal Palace filled with busts of these engineers.

When the fact was known that we were American engineers the doors of welcome were opened wide to us all through Great Britain, and when we arrived in France we found that a civil engineer was one of the Ministers of State and another the President of the French Republic. When he met the American engineers he told them that he received them, not only as Americans, but as his comrades, and the mere fact that they belonged to that profession was a passport to them, not only to all the places of interest which they wanted to visit, but also to all social entertainments, and they came away—the whole 300 who paid that visit last year—came away with the most gratifying impression of the high social position which our profession occupied abroad, and with the hope that by strong efforts to raise the standard in this country a similar recognition might be obtained here.

I thank you, gentlemen, for your attention.

Adjourned.

It appeared to be the consensus of opinion of 100 members and guests present, that the annual meeting of January 8, 1890, was in every way a success and likely to promote the welfare of the Society and a greater public interest in the profession—a consummation of vital importance.

JOHN W. WESTON, Secretary.

ENGINEERS' CLUB OF ST. LOUIS.

32 ST MEETING, FEBRUARY 5, 1890.—The club met at 8:15 p. m. in the rooms of the Elks' Club, President Nipher in the chair; twenty-seven members and three visitors present. The minutes of the last meeting were read and approved. The executive committee reported the doings of its eighty-third meeting, approving the following applications for membership; J. I. Ayers, C. W. Connet, B. L. Crosby, J. H. Curtis, G. H. French, and A. Winslow. They were balloted for and elected. The following applications for membership were announced: W. E. Barns, editor of *The Age of Steel*, endorsed by E. D. Meier, J. B. Johnson and W. H. Bryan; Emerson McMillin, president Laclede Gas Light Company, endorsed by E. D. Meier and W. H. Bryan; John H. Pope, civil engineer with the Union Bridge Company, endorsed by J. B. Johnson and Julius Baier.

The secretary explained that if these names were voted upon at this meeting they could probably be included in the official list now being prepared. Moved and seconded that a recess be taken to permit the executive committee to consider and report upon these names. Mr. Robert Moore stated that he thought this would establish a bad precedent, as the custom had grown up of allowing applications to lie over two weeks, during which time members had an opportunity of looking into the character of the applicant before voting. The motion was on vote lost.

Mr. Geo. W. Dudley then read a paper on "Tests of Water Works Engines." He explained the meaning and origin of the term "duty." He explained in detail the precautions necessary to be taken in making duty tests, in order that the results might be of value. He submitted reports in detail of two tests of compound condensing duplex direct-acting pumping engines, one of 3,000,000 gallons capacity per

twenty-four hours, giving a duty of about 62,500,000 foot pounds per hundred pounds of coal; the other of 5,000,000 gallons capacity, giving a duty of about 75,000,000

In the discussion, Mr. Bryan called attention to a simple rule for comparing the efficiency of pumping engines with ordinary steam engines, the evaporation in pounds of water per horse power per hour being equivalent to the constant 1980, divided by the duty expressed in millions of foot pounds, based upon ten to one evaporation. He called attention to remarkable results that were being guaranteed by makers of compound and triple-expansion condensing engines now being built for electric light purposes.

Col. Meier called attention to the necessity of a clearer understanding of this subject of duty, and the desirability of reducing results to a common basis in order that intelligent comparisons might be made.

Prof. Johnson stated that if due allowance were made for engine friction he thought the results would not be so unfavorable to pumping engines as shown by Mr. Bryan. He also called attention to the value of such tests as those reported in Mr. Dudley's paper, and thought they should be made oftener. He explained the construction and use of the Clemens Herschel meter for determining the amount of water pumped.

Prof. Gale stated that pumping engines were subject to certain losses, due to friction, for which they were given no credit. This being allowed for, the efficiency would be increased. He also showed that the cost of high duty engines was an important item, as the increased interest and depreciation accounts might overbalance the saving. He also showed that pumping engines were usually put in of greater capacity than required, so that they were operated under a disadvantage.

Mr. Holman called attention to the relative importance of duty as compared with other items of expense in pumping water. In this city the coal bill was less than half of the total cost, the items of labor and repairs being of almost equal importance. He also expressed great doubt as to the reliability of the tests of the old Cornish pumping engines, which were usually held up as standards. Messrs. Ferguson and Seddon also took part in the discussion.

The secretary then read for Mr. J. H. Kinealy a paper entitled "Some Mathematics on Ventilation." The author tested the commonly accepted rules of practice by mathematical deduction, with the result of showing the practice to be well founded. In the discussion Prof. Gale stated that the intention of the author was to investigate what difference, if any, must be made in the provision for ventilation between a room occupied only temporarily and the same occupied continously.

Prof. Johnson suggested that mathematical papers of this kind had better be read by title only.

Adjourned.

322ND MEETING, FEBRUARY 19, 1890.—The club met at 8.15 p.m. in the rooms of the Elks' Club, Vice-President Burnet in the chair; thirty-two members and eight visitors present. The minutes of the 321st meeting were read and approved. The Executive Committee reported the doings of its 84th and 8 th meetings, approving the following applications for membership: Wm. E. Barns, Emerson McMillin and John H. Pope. They were ballotted for and elected. Applications for membership were announced from Wm. A. Neff, Jr., Sewer Department City of St. Louis, endorsed by O. W. Ferguson and Wm. Wise; and Julius Pitzman, City Surveyor, endorsed by M. L. Holman, Geo. Burnet, Henry Flad and Robert E. McMath. These were referred to the executive committee

Prof. Johnson then read Mr. Edward H. Connor's paper on the "Substructure of the Cairo Bridge" The paper was accompanied by drawings, showing the spans, piers and caissons; also by numerous tables, and the complete specifications of the bridge. The paper explained the work of construction in detail, and the difficulties met with in various parts of the work. The tables gave the results of numerous tests on cements, showing the effect of different proportions of salt, the effect of freezing, the effect of fine grinding, etc. The results were given for both Portland and Louisville cements. A general discussion followed, participated in by Messrs. Crosby, Kebby, Holman, Ockerson, Burnet and Ferguson. Mr. Barr, of

the firm of Anderson & Barr, who were the contractors for the substructure of this bridge, was present, and related some of his experiences.

Under general discussion, Mr. Willard Beahan was called upon for some information regarding the outlook for engineers in South America, he having recently returned from that country. He stated that the prospects for American engineers were excellent at the present time. Railroads are few, but a large number are in prospect. Municipal engineering was just being taken up. The prices secured and salaries paid were good. Most of the engineers now in that country are French, there being only a few from America and England.

Adjourned.

323RD MEETING, MARCH 5, 1890.—The club met at 8.15 p.m. in the rooms of the Elks' Club, Laclede Building. President Nipher in the chair; thirty-one members and six visitors present. The executive committee reported the doings of its 8 th meeting, recommending for election to membership, Wm. A Neff, Jr., and Julius Pitzman. They were ballotted for and elected.

The special committee on banquet to Mr. T. S. Mendenhall, submitted a final report, turning $15 into the treasury. On motion, the report was accepted and the committee discharged.

Mr. Seddon, chairman of the library committee, called attention to the fact that the club room was being kept open every Saturday evening, and he trusted members would make greater use of it.

Mr. Willard Beahan then read a paper on "American and Foreign Railways." This paper was prepared on short notice to take the place of the one announced on the regular programme, it having been found impossible to complete the latter in time for this meeting. Mr. Beahan's paper was a report of a recent trip he had made, and gave the results of his observations of the countries passed through, with particular reference to their railways. For the purposes of this subject, Castilian America could be considered as a foreign country. Mr. Beahan's observations extended to Panama, a number of countries in South America, France, England, Scotland and Ireland. Some description was given of the topography of the countries traversed, from the point of view of a railway locating engineer. The road beds of the railways were described, together with their ties, rails, ballast, grades, curves and bridges. Some information was also given as to the locomotives used, and the rolling stock, speed, and the class and nationality of men employed to operate the roads. Comparisons were made between American and foreign railways on the points of original cost, maintenance, and operation, showing wherein American roads excelled, and wherein they might learn something. The iron ties used in South America were described. A brief description was also given of the Forth Bridge. The discussion was participated in by Messrs. Robert Moore, J. B. Johnson, Meier, Ferguson, Curtis, Crosby, Long and Gayler.

Adjourned. WM. H. BRYAN, Secretary.

ENGINEERS' CLUB OF KANSAS CITY.

FEBRUARY 28, 1890.—Friday evening, February 28th, the Club held its Annual Dinner at the St. James Hotel. There were thirty-three present, including twenty-two members and invited guests. After a most satisfactory repast, toasts were responded to by President W. H. Breithaupt, O. B. Gunn, F. E. Sickels, K. Allen, A. J. Mason, G. W. Pearsons and D. W. Pike, and entertaining reminiscences of engineering experience were given by Mayor Davenport, Major Gunn, Mr. E. I. Farnsworth and Mr. Henry Goldmark. Mr. Wm. B. Knight filled the office of toast master in a most satisfactory manner.

MARCH 3, 1890.—A regular meeting was held in the Club Room at 8 P. M. President Breithaupt in the chair, K. Allen, Secretary, fourteen members and three visitors being present.

Minutes of last regular meeting and of the meeting of the Executive Committee were read and approved.

Mr. F. W. Tuttle presented a report from the Dinner Committee as follows: Total expense, $119.75; amount collected, $65.00; deficit, 54.75.

On motion of Mr. Mason it was voted to apply to this from the treasury $17.75, being the cost of printing and plates for two guests.

On motion of Mr. Farnsworth it was voted that the remaining indebtedness be paid by the Club.

On motion of Major Gunn it was voted that the Secretary draw up a subscription to present to the members present for the purpose of defraying the deficit from the dinner.

On canvas of ballots R. J. McCarty was elected a member, and it was voted to amend Article V, Section 1 of the Constitution and Section 3 of the By-Laws.

On motion of Mr. Mason it was voted that the next regular meeting be held the second Monday in April.

The Secretary presented in behalf of Mr. Thomes a large number of valuable Government Reports.

On motion of Mr. Goldmark it was voted to accept the generous gift of Mr. Thomes with thanks and that it be so recorded in the annals of the Club.

Major O. B. Gunn read a letter received from L. F. Green, Esq., of Baldwin, Kas., commending the Club on its prosperity, and the answer sent him.

Edw. J. Lawless was proposed as Associate by K. Allen and W. B. Knight, Carl Wenntrock was proposed as Member by O. B. Gunn, J. H. Grove, E. A. Harper, Ewd. Butts and C. E. Taylor.

Mr. G. W. Pearsons read a paper on "Photography applied to Surveying."

"The focal length of camera best adapted to this work is from 12 to 1[illegible] inches. The image formed on the sensitive plate represents a series of right lines passing through the center of the lens from the landscape to it. If, therefore, the plate is in correct position it will give a mathematically correct copy, capable of direct measurement, and to a much greater degree of accuracy than would be at first imagined.

"For purposes of precision proper regard must be paid to the positions of the plate and camera. The former must be truly vertical, and, for a proper definition of the horizon, its edges should be horizontal. The angle covered by the plate must be known, and sufficient lap should be allowed to join consecutive prints.

"The centres of plates should be correctly located, vertically and horizontally, as they must be measured by a scale of tangents from the vertical centre and horizon. The focal distance should remain fixed.

"After taking a series of views from the first station, proceed to the next point and take another set in the same manner, intersecting the first. The points of observation being known, these intersections determine any desired point in the field of view. The third station bears on the first two, the fourth on the second and third, etc., forming a continuous triangulation on which most points may be defined by three intersections. Any point so determined is also defined as to height by the tangent of its distance from the point of observation. The plates therefore give vertical as well as horizontal definitions of the field and with a degree of accuracy which will surprise the engineer."

Adjourned. KENNETH ALLEN, Secretary.

BOSTON SOCIETY OF CIVIL ENGINEERS.

FEBRUARY 19, 1890.—A regular meeting was held at the American House, Boston. President FitzGerald in the chair. Forty-nine members and seven visitors present.

Messrs. Frederick W. Farnham, Willard M. Foster, Alfred E. Nichols and Fred S. Pearson were elected to membership.

The President announced the death of Lincoln Cabot, a member of the Society, which occurred at Honolulu, Sandwich Islands, Dec. 11, 1889. A committee consisting of Messrs. Tinkham and Blodgett was appointed to prepare a memoir.

On motion of Mr. French the sum of $50 was appropriated for the general expenses of the coming annual dinner.

Mr. Rice, for the committee to nominate officers, submitted a verbal report and the Society proceeded to ballot for a Vice-President and a Director for the terms expiring at the annual meeting in 1891. Messrs. Hodgdon and Eaton acting as committee to count ballots.

Mr. William E. McClintock was elected Vice-President on the second ballot and Prof. W. S. Chaplin, Director on the third ballot.

President FitzGerald brought to the attention of the Society the desirability of taking some steps toward procuring a club house and spoke substantially as follows: Several years ago at one of the annual dinners I had occasion to express the hope that at some time in the future this Society might have a club house of its own in Boston. By many this idea was received with incredulity, but by all, I believe, with enthusiasm. Since then very little has been actually accomplished towards this desirable end, but I believe the resources and strength of the Society have been growing to such an extent as to render the attainment of permanent quarters a matter of the near future. I wish to bring this subject seriously before the Society at this time for the purpose of getting an expression of opinion from the members present to-night. It seems to me to delay longer is to lose time unnecessarily. Whether we can afford to start rooms of our own with a cafe attached, or whether we had better join some other society with the same object in view, I leave for you to decide. In this connection I trust that we shall consider that the Boston Society of Civil Engineers has had a long and honorable career, dating from 1848, and that while we sit idle in this matter, other organizations spring into being, almost every day which have better accomodations than we can boast.

The subject was very fully discussed by the members present and on motion of Mr. Blodgett it was voted: "That the Committee on Common Headquarters be requested to report in print in time for the same to be sent to members before the April meeting and that the further consideration of that subject be assigned to that meeting.

The President appointed Messrs. H. H. Carter and F. P. Spalding tellers to canvass the ballots for officers at the coming election.*

Captain Eugene Griffin, General Manager Railway Dep't., Thomson-Houston Electric Co., read a paper on "The Transmission of Power by Electricity." The paper was discussed by Messrs. Blodgett, Pearson, Tilden and others.

Adjourned. S. E. TINKHAM, Secretary.

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*Mr. Carter having declined the appointment on account of expected absence from the city, the President has since appointed Mr. F. O. Whitney a teller.

Editors reprinting articles from this journal are requested to credit both the JOURNAL *and the Society before which such articles were read.*

ASSOCIATION OF ENGINEERING SOCIETIES.

ORGANIZED 1881.

Vol. IX. April, 1890. No. 4.

SOME METHODS OF HEATING AND VENTILATING SCHOOL HOUSES.

By WILLIAM E. McCLINTOCK, MEMBER OF THE BOSTON SOCIETY OF CIVIL ENGINEERS.

[Read December 18, 1889.]

I appear before you this evening to speak on a question of great importance, although classed by some of our best sanitarians as amongst the lost arts. I approach the subject with considerable trepidation, feeling that I have struck into a topic that would require a life time to master with any degree of certainty.

There is no doubt in my mind that the conditions of life are at the present time so different from what they were one hundred, or even fifty years ago; that the demand for better facilities in every part of our living are so much greater now than at that time that we cannot compare the past with the present.

There is no doubt in my mind that the poorly ventilated school room has had its share in producing many of the ills of the present generation.

As our country increases in wealth and population the tendency is to more and more depart from the rural and take up with the city life.

This means more brain work and less physical labor and a consequent lessening of the powers to resist certain forms of disease.

It is claimed by many that the great prevalence of near-sightedness amongst the Germans results from poor school ventilation. Examinations of the air of their schools certainly show it to be heavily charged with carbonic acid and in a bad condition. We are well aware of the fact that in a school room not properly ventilated the pupils show in their every look that this system is not in its normal condition. There is a lack of life and energy, the face is flushed, the eyes are heavy and dull.

In our own work we find that the brain refuses to work to its best in a room where the air is not pure.

What constitutes pure air, looked at from the standpoint of health and comfort, may be hard to exactly determine; but fortunately there is a comparatively easy test of the purity by determining the quantity of carbonic acid gas in it. A person's lungs will exhale a certain amount of carbonic acid gas; and with this there are certain organic matters that are to a certain extent poisonous. The labor of ascertaining the amount of organic matter is very difficult, while it is comparatively easy to get the carbonic acid; and so the carbonic acid is determined when we wish to make comparisons.

The normal amount of carbonic acid in the air is from three to five parts to the 10,000, while an addition of two to four parts makes a perceptibly bad impression. While we may not arrive at perfection in this matter, we can approach to a point that may be said to be safe.

On authority of such able men as Dr. Parks, of London, and Surgeon Billings, of our own country, the general practice of to-day is to call ten parts of carbonic to the 10,000 the maximum allowable amount in a room where many persons are assembled together.

The air as it is exhaled from the lungs leaves the mouth at a temperature of about 100 degrees; and although the carbonic acid in the exhaled air is great, yet the loss in density caused by the increase in temperature is sufficiently great to cause the air to rise toward the top of the room, where it rapidly mixes with the other air, gradually lowering the standard of the whole room.

This carbonic acid gas has at times been a stumbling block to many, and has, in the past, given rise to a theory that the only way to ventilate a room was to furnish openings at the floor and allow the heavy gas to flow off like water. Although such a condition might exist in a room very near air tight and with a temperature unchangeable, yet where the temperature is at all changeable the different gases must mix thoroughly.

It strikes me that the problem sought is rather one of how much of the bad can we take mixed with the good and how shall we introduce the good and get rid of the bad.

I find, after wading through long arguments, where all the conditions are considered, that if we can get from 25 to 30 cubic feet per minute per scholar we are getting very good results, and we can keep the carbonic acid to the required ten parts in 10,000.

It is the purpose of my paper to rather give some of the methods of heating and ventilating to be found at the present time than to theorize.

I shall first refer to a church which has a seating capacity of 750 and an air space of about 150 cubic feet per person when full. There is a round ventilator in the center of the ceiling connected by a box with a brick tower having a window on each of its four sides. The box has a cross section of $3\frac{1}{4}$ square feet, and with the ordinary velocity of, say 3 feet per second, would allow about 35,700 cubic feet per hour to pass off. This amount, with the air space above referred to in the room, would seem to give very fair results; but on several occasions that I looked at the outlet box I found the damper in it closed. I at last succeeded in inducing the sexton to keep this damper open, but even then the results did not change. I then went to the tower and found that the large windows, before referred

to, were entirely boarded up on the inside, leaving no chance for air to pass either in or out. By removing the boards from these windows we now have a fair flow of air. I find on an examination that most of our churches have this method of ventilation, which must be very extravagant, to say the least, as the heat passes from the registers in the floor directly up and through the roof, to the extent of the capacity of the outlet box. In addition to the extravagant feature of this method as to fuel, there is the worse feature of leaving all the corners with but very little pure, or even warm air in them.

The effect on myself in a poorly ventilated room is to render me sleepy; and what I have for years supposed to be due to original sin, which permitted me to sleep during service time, I now think must be due rather to poor air.

We have often seen the small district school house in the country with one room and windows on three sides. If we should go inside one of these rooms we would probably find a large box stove burning wood, which heats the air in the immediate vicinity to an intense point, while the air in the farther parts of the room is hardly warmed at all.

There is sufficient heat generated by the stove to heat the small room in all its parts to a comfortable degree, but for want of proper direction this is not done. The stove has to heat the air coming in contact with it, sending it in a rapid current to the ceiling, its place being supplied by other air from the room. This does not give a good degree of circulation in the room and surely does not give a change of air. If the windows were to be double and a cold air box be brought from the outer air and through an opening in the floor under the stove, while the stove is cased in with iron or other metal, leaving the top open, we could easily heat pure fresh air in quantities to fill the whole room. Having provided for admitting fresh warm air, we must now provide for carrying off the colder air that has been vitiated by use through properly-located extracting flues. This method has been used in several places with excellent results and at small expense.

I call to my mind some school houses that I have looked over, and will now show you how little attention is given to this subject by school committees and others having the matter in charge and how really necessary was the law that puts the inspection of the buildings in the hands of those who do not have to look out for the means of furnishing the money to make the changes.

A brick building having 12 rooms was actually planned to have two 20 inch flues for ventilation, having a 15 inch iron smoke pipe passing up the centre to give the needed power or draft. Each room was to be connected into the common flue, with no means of preventing the air from passing from one floor to an other. The heat was to be direct steam.

To get any decent change of air would require a velocity in the flues of about 50 miles per hour, even provided there was any air in the rooms to take out. After long discussions this plan was so changed by the committee having charge as to give good sized flues from the rooms, while fresh air was taken direct from outside and passed over steam radiators

located in the room to be heated. I am unable to give any figures at this school, but do not think they would be wholly satisfactory.

A wooden four-room building I examined had eight by twelve brick flues, for the lower floors, while the upper floors used the unfinished breasts beside the chimney for ventilators. On closer examination the breasts were found to end in the attic with no openings from attic to outer air. In these cases the air flowed through the registers at a velocity of about 2 feet per second, which, taken with the size of the flues, would give only 5 or 6 cu. ft. per min. per scholar.

A two-story four-room brick building seemed to have small registers into brick flues 8 × 12 inches, two rooms using a common flue. The air here was simply unbearable; and an inspection in the attic showed that the brick flues were built on the same principle as a cannon, viz., with hole at one end only.

A two-story wooden building of two rooms had a very small flue and a still smaller register. The theory in all the older types of buildings seemed to be to get a register at any cost, and never mind the flue.

I shall now have a word to say of some of our more modern buildings—buildings that have very pleasant exteriors as well as interiors—buildings that have been planned by so-called architects who should never have been permitted to foist such abortions on a long suffering public.

It is now my intention to give a short description of some of the buildings I have examined to show what we have in our midst, leaving it for you to draw deductions.

A 14-room brick building, with hall, was heated by hot air furnaces with no extracting flue worth mentioning. Much fault was found with this building by the parents on account of headaches and other ailments among the children attending the school.

A two-story 4-room building of wood as originally planned by the architect showed a 10-inch square wooden flue that could not be built on account of the valley rafters; and even if it could have been built, it was to end in the open attic without openings of any kind to the outer air. The changes in original plan delivered the four flues from the rooms into a cupola with no more than one half the sums of the four sections. This building was heated by direct steam by the use of lines of pipes around three sides of the rooms.

A building of exactly the same plan as the last was planned to be heated by hot air furnaces with plaster finished extracting flues ending in a close attic, which later on were carried into a cupola. Direct steam was put in instead of hot air.

Question.—How much air passed out of the ventilators?

An eight-room two story wooden building located in a beautiful spot, with cheerful and finely finished and furnished rooms, was heated by the same lines of steam pipes on the three sides of each room.

The ventilation is by tin pipes in each of the outer corners of the building and registers at the top and bottom of each room.

The lower rooms have 8-inch pipes extending to the attic floor.

The upper rooms have 12-inch pipes starting at the second floor and placed outside the smaller pipes. The outer pipes from one half of the

building join into a pipe of the same size (12-inch) and end in a brick flue having a 12-inch glazed pipe passing through the centre for a smoke pipe. The required velocity of the air in this 12-inch pipe as it enters the brick flue to change the air of its part of the building in say, 20 minutes, is 45 feet per second. The required velocity in same pipe to ventilate but *one* room is a little more than 10 feet per second. The actual observed velocity in the pipe was from 2 to 3 feet per second.

A four-room two story wooden building has the same line of steam pipes on three sides of the rooms. The ventilation in this building is by 12-inch tin pipe from each room, the same entering a common brick flue 3 feet by 2 feet in the attic and having a glazed smoke pipe passing through the flue. The main defect here is the entire lack of any means of admitting fresh air.

A 12-room two story building heated by hot air furnaces had no extracting flues except some old and disused chimney flues about 8 x 10 inches with registers near the top of the rooms. The basement of this building was partitioned off into a series of rooms and a large quantity of rotten wood added its smells to the water closet tanks to sweep through the whole building.

I could easily cite many other cases equally bad as the ones already referred to, many of which will probably continue to exist until some power other than the local boards order the changes made. I do not say this out of any disrespect to these boards; as I find they have, in many cases, endeavored to move in the matter, but have been prevented by their townsmen, who began and finished their education in just such places, and who seem to think the present generation should do the same, and not tax them for any of your new-fangled notions.

Mr. President, I feel that we should, to a man, unite in rendering all possible assistance to the State Inspectors, while they push on in their strong effort to work a much needed reform.

It may be that they will make mistakes, but in a short time they will get at the bottom of the matter; and our children will rise and call them blessed. Even with the short time that they have been at work, there is a marked improvement; and there is bound to be a still greater advance within the next one or two years.

Having touched on some of the buildings we should call defective, let us now take up the question, how to improve them?

There is no doubt but that heating and ventilating must go hand in hand; they cannot be separated; and no great improvement can be made unless one conforms to the other.

First: We cannot introduce fresh air in any quantities into a room without first removing an equal quantity of the air already in the room.

Second: We cannot take air out of a room unless we introduce an equal volume.

Third: We cannot keep the air of a room good unless we introduce enough fresh air to mix with the air already in to thoroughly dilute the same and keep it to a certain standard.

Fourth: In the introduction of fresh air we must avoid cold drafts, which means the introduction of large quantities of air at about the re-

quired temperature and through a flue of sufficient section to give a low velocity.

Fifth: The warm air inlet and cooled outlet must have such relation to each other as to compel the air to thoroughly mix and intermingle in all parts of the room with but slight variations in temperature.

The solution of the above problems has brought out some ingenious methods to convey heat in and foul air out, some of which I shall now describe.

SHURTLEFF SCHOOL, CHELSEA.

This is a three-story stone building with sixteen rooms and a hall equal to two more rooms, and the coat rooms to correspond.

The system in use in this building is what is known as the Smead & Northcott and includes the heating, ventilation, and sanitation.

The building is divided into two equal parts, each being treated exactly alike.

The fresh air is introduced through windows in the basement into chambers. Thence it passes into brick flues, and by means of a damper can be passed directly into the rooms, or first passed over the heater and then into the rooms, or part of it can go by each channel and be admitted to the room at any desired temperature by working the damper.

The heater consists of a long fire-box protected by a corrugated iron lining that allows an air space between it and the casting of the box itself and which prevents the fire-pot being heated to a red heat.

The flame and smoke pass out of the rear end of the fire-pot, then back through a series of tubes to the front end of furnace, when it again passes to the back end through a smoke pipe, and thence to the smoke flue.

The air to be warmed thus comes in contact with a very large surface at a comparatively low temperature. The damper that allows the warm and cold air to mix is regulated by a crank in the school room, and is worked at the will of the teacher alone. The warm air is introduced into the rooms through a register in the wall about 8 feet above the floor, except in one or two cases where the construction of the building would not permit.

The foul air extractors are in the side walls at the floor on two or three sides of the room other than the side with the heat register.

The extractors are in the aggregate a little larger than the inlet for warm air. There are three inch strips, fastened to the floor timbers and at right angles to same, that allow of a free circulation beneath the floors which are nailed to these strips. This last method has I think been abandoned at the present time on account of the extra danger of the rapid spread of fire.

Vertical wooden flues, tin lined, pass down from each room, connecting with the space under the floors, and ending in a large brick gathering room.

From the gathering room the air passes into and through a tunnel that doubles on itself and then, by a right angle turn, ends in the side of the

bottom of the main stack, which is of brick and ends four feet above the roof. The inside dimensions of this stack are 3.55 x 5.62.

A small heater in the stack at the cellar floor will heat the stack to a temperature of 92° if desired, creating a current having a velocity of between 10 and 11 feet per second.

An arrangement of closets and seats over the tunnel referred to furnishes a sanitary convenience. The foecal matter is received onto a brick floor so laid on iron as to give a six inch air space beneath it. On the boys side the urinals discharge by pipes into the same tunnel. All of the moisture seems to be evaporated from both the foecal matter and the urine leaving a dry and almost inodorous substance which can be saturated with oil and be burned if so desired. The draft is at all times down through the seats when the covers are raised, with a velocity of from 6 to 10 feet per second.

No smell can be perceived either in the closets or urinals, although some 800 or 900 pupils use them.

Air metre tests give a good flow of air under various conditions and in the direction planned and at rates that show the air in the room to be changed in from 9 to 16.4 minutes. The best results are when the stack is heated thoroughly and the air moves with a mean velocity of 5.5 feet per second. Allowing the school to be full, we have 450 pupils to each stack, and with 20 cubic feet per pupil, we have to discharge 9,000 cubic feet per minute, or at the rate of 5.5 feet per second.

In order to get 30 cubic feet per second we must have a velocity in the stack of 8.5 feet per second.

A few tests have been made in this building to ascertain the amount of carbonic gas. These tests were made just before the noon closing, and showed at the breathing line 14.36 parts, and at the outlets 16.53 parts to the 10,000. This showing is rather a disappointment, but goes to prove that in order to get as low as 10 parts in 10,000 we must allow more than 20 cubic feet per minute.

These results compare favorably with Prof. W. R. Nichols examinations of 29 school rooms in Boston in 1880, when he got a mean of 15.6 parts per 10,000.

The cost of introducing the whole of the heating, ventilation, and sanitary appliances, was $7,000.

Some complaint has been made by a few of the teachers that cool drafts were felt to a disagreeable extent in certain parts of the rooms; but shields have been so placed as to partially obviate this trouble.

The air seems at all times to be good to a person going in from the outside; and the children seem to look well and work well.

BROADWAY SCHOOL.

This is a two story wooden building with four rooms, each 28x32 feet, and 14 feet high.

The building was originally heated by steam pipes running around three sides of each room, the steam being furnished by a tubular boiler. The ventilation consisted of an outlet flue; but no means were furnished to allow fresh air to come into the rooms.

There are 56 pupils in each room.

The intention was to allow 25 cubic feet per minute per pupil when the building was remodeled in the year 1888.

The steam pipes were left in their original position in order to act as supplementary heaters during very cold weather, and are intended to be used when the temperature is extremely low.

Steam coils are placed in the cellar. one each for a room, and these are connected directly with the outside air by flues having a clear opening of 30 x 18 inches covered by a wire netting of three-eighths inch mesh. The flues allow the air to pass over the steam coil and thence into the school-room, being delivered into the room at a point about 8 feet above the floor and on the side with no windows.

The amount of air admitted through these flues can be regulated by means of a damper in each flue.

The foul air is removed by ducts built of lath and plaster work up to the attic floor; and from there the four ducts join together into one in the center and near the roof have an inside measurment of 31.5 x 40.5 inches or 8.86 sq. ft. The section of the ducts from each room is equal to 3.76 square feet. The main ventilating shaft ends just above the ridge of the roof in a cupola having wire netting around the openings to keep out the birds, &c. In the upper part of the main ventilating shaft there are six lines of one and a quarter inch steam pipe passing around the four sides and heating the air of shaft.

The flue for ventilation in each room has a register in the wall at the floor and one at the top of room. The lower register is the same size as the warm air flue, 30 x 18 inches, the upper one being slightly smaller, 18 x 10, for no other reason than that it was built so and not changed with the rest of work. The ventilating outlet is on the same side of room as warm air inlet. The expense of refitting this building as described was $450, which includes the indirect steam heaters. cold air boxes, flues for warm air to rooms, ventilating ducts from attic floor through the roof, and all the registers and fitting.

Having made the changes described we were anxious to learn what the results were; and for this purpose several experiments have been made to see the amount of air passing into and through the rooms, and its quality in the rooms.

The State inspectors in their tests showed that there were 25 cubic ft. per minute per pupil delivered into the rooms and taken out of the ventilating flues.

My own tests have been limited and were made under conditions not the best that could be desired, viz., on a warm day when the rooms could not be cooled without having doors and windows open. There was a moderate southwest wind blowing at the time and the outside temperature was 60°, while the rooms were 70° and the top of main ventilating shaft 76°. I found the amount of air discharged from each room to be about the same, viz:

Northwest lower room 917.44 cubic ft. per minute or $16\frac{1}{2}$ cubic ft. per minute per pupil.

Northwest upper room 803.56 cubic ft. per minute or $15\frac{1}{2}$ cubic ft. per minute per pupil.

Southeast upper room 793.36 cubic ft. per minute or $14\frac{1}{5}$ cubic ft. per minute per pupil.

Southeast lower room 830.96 cubic ft. per minute or $14\frac{8}{10}$ cubic ft per minute per pupil.

These trials were made in the upper ends of the flues just as they enter the main shaft.

Trials in the main shaft above the points of delivery for the individual flues made at another time gave as the rate for the whole building 16. 8 cubic feet per minute per pupil. The windows and doors were also open during these trials; and the air in the building was probably as cool as could be wished.

There are two slight changes that could be made in this building that would probably add to the efficiency, viz.: The steam for the coil in the top of main flue should come from a separate small heater or from the main boiler with shut-offs for the other rooms; as the rooms are heated too much when the outside temperature is high if more than two pounds are indicated on the gauge, while that amount will give good results in the shaft.

The second change is to divide the cold air shaft just before entering the coil box with a damper to allow the cold air to pass directly into the rooms or through the coil for heating or to be mixed to give any required temperature before entering the rooms.

The top of main shaft wants to be as hot as possible to give power enough to draw forcibly from all the rooms.

One other evil in this building results from the direct steam pipes in the rooms. These are often used by the janitor to heat the rooms in the morning quickly, but they are not always closed when the session opens. The result is, too much heat; and it is necessary to open the windows for comfort. An examination of the air of the rooms shows 16.99 parts of carbonic acid gas per 10,000. This I think is in excess of what would be had now, but agrees very well with my figures as to the quantity of air per scholar per minute as will be seen by referring to my previous figures and only goes to show that the carbonic acid gas increases inversely with the amount of air per pupil.

CARTER SCHOOL, CHELSEA.

This is a four story brick building and as remodeled has what is known as the Fuller & Warren system of heating and ventilating.

There are 16 rooms, a hall equal to two rooms, and the usual coat rooms.

The fresh air is introduced through galvanized iron boxes opening through the cellar wall, two at each end of the building dividing the same into four equal parts. The air passes from the air boxes into the brick chamber where the heater is located, entering the same at the bottom. The heated air passes from the top of the heating chamber into brick flues that lead directly to the different rooms. The hot air flues pass to the bottom of the furnace, where there are openings that allow the cold

air to pass into the same and then into the rooms direct, if desired; or where it can be mixed with the heated air to any desired temperature by means of a damper that is controlled by either the janitor, by a chain at the furnace, or by the teacher with a crank at the inlet register in the schoolroom. A double-acting damper closes the cold air inlet before passing to the heater and at the same time opens the down extracting flue from the rooms, allowing the warmed air from these rooms to be heated over again during those times when school is not in session. This is no doubt a good thing as far as economy of fuel is concerned, but it is leaving a great deal to the honesty of the janitor; or it affords a great temptation for him to be late about his fires in the morning if he so desires. Of course this damper should never be used when school is in session.

The warm air is introduced into the room at a point about 8 feet above the floor through the side wall. opposite the windows.

The foul air extraxtors are located in the floor or side walls at the floor and are of tin lined wooden construction and pass down to a brick chamber in the cellar below the concrete floor level from which point they pass into the base of the main stack, which is of brick, and passes up to a point about 4 feet above the roof. A small heater in the base of this stack, fired from the cellar raises the temperature in the stack so as to give a good flow of air up shaft and suction down from the rooms. The main stack has an area of 4 x 7 ft., and one is located at each side of building taking the air from 8 rooms.

Area of down extracting flues is about 640 square inches.

The heater used here is a round furnace with tubes in the top to give an increased heating surface.

The State inspectors have got as high as 30 cubic ft. per scholar per minute from all the rooms. At the only time I tried the discharge I found the air flowing through the stack at the rate of 11,620 cubic ft. per minute, while 12,000 would allow 30 cubic ft. per minute per pupil.

Although I found this to be the mean flow I also found that in certain rooms we failed to get so good a result, the amount lessening somewhat as we reached the upper floors. Trials made since show this defect to be remedied mostly, if not wholly; and it is safe to say that the pupils are getting the full 25 if not 30 cubic ft. needed.

A test of the air in this building showed there were but 8.63 parts of carbonic acid gas at the breathing line and 9.08 parts at the outlet per 10,000. This result was obtained in a room on the second floor at 11:30 just as school was let out, but before the doors had been opened.

The cost of putting in the heating and ventilating was $6,456.

I think I have said enough to show that there have been cases of badly ventilated buildings in which school children have had to work much to their disadvantage; and that changes are taking place that are giving good results theoretically, and which will give to our children what is of far greater advantage than an education, and that is, good health.

I feel that this subject demands that every engineer or architect who plans for a public building is derelict in his duty if he does not insist on thorough plans for ventilation of the same. The responsibility largely rests with us and we should see that our patrons are not misdirected, even

if some of the details of ornamentation have to be omitted. The old Egyptian and Roman works that can be looked at to-day, after centuries have passed, have long outlasted the more ornate Grecian works. If we would build monuments to ourselves let them be of the kind that help our fellow men.

DISCUSSION.

THE PRESIDENT.—I have asked several gentlemen who are interested in this subject of heating and ventilation to come here to-night, but before calling upon them it seems to me it would be well for us to go on with the discussion on Mr. McClintock's paper. A number of gentlemen who are now present were unable to go with us to see the school houses to-day, and perhaps they would like to ask some questions in regard to the subject of the paper before we proceed to another matter. The chair therefore awaits discussion.

MR. SIDNEY SMITH.—The inquiry has often been made of me if some instrument could not be devised similar to the thermometer, which could be put into private apartments for the purpose of indicating when the air was in a proper state to be inhaled, or when it had become so vile and impure that the room was unfit for occupancy. I would like to ask Mr. McClintock if he is familiar with an instrument invented, I think, by Dr. Angus Smith, of England, some ten or twelve years ago for that purpose, or, if, in Mr. McClintock's opinion, there is a prospect of our having such an instrument which will act as a guide to a teacher in a room where the air is gradually becoming vitiated, thus rendering it difficult for the teacher to judge when the proper time has arrived when a fresh supply of air or a larger supply of air shall be introduced.

MR. MCCLINTOCK.—I think that the instrument that Mr. Smith refers to is for the purpose of determining the quantity of carbonic acid gas which is in the room, if I remember the description of it; and it is a simple method of finding out in a general way the amount of carbonic acid gas; and it requires some slight education and some skill to work it properly. I should judge from the description of it that it resembles the bulb instruments which are used by the State inspectors in their examinations. The instrument consists of a tube filled with lime water; to this tube is attached a rubber bulb, by pressing which the air is forced through the lime water. According to the number of fillings of the bulb which are required to make the lime water opaque we judge the purity of the air, counting the number of bulbfuls of air required; and referring to a table, we get the parts of carbonic acid gas in ten thousand of air. I do not know of anything except the sense of smell that is self-acting, and by which you can discover whether the air is pure or foul.

MR. SMITH.—It is very easy for a person going from the pure air into a room to tell whether or not the air in that room is pure, or at least fairly

good—he can, of course, tell at once if the air is very impure. But often, when we have been for some hours unconsciously vitiating the air of a room, someone comes in from the fresh air and tells us that our apartments are very close.

MR. McCLINTOCK.—I think that the authorities agree that with from three to five parts of carbonic acid gas to ten thousand, the air is very good; it is normal air outside; but when it reaches two parts above that the change begins to be perceptible, and when it has reached four to five parts above that the air becomes disagreeable—that is, to the sense of smell. I do not know of any other way of testing it than by the sense of smell, just as the only way of testing steel is by observing its color. At all events, I am not familiar with any other way of determining its condition.

MR. E. P. ADAMS.—The ordinary way of discovering the approximate percentage of carbonic acid gas in the air, might, I should think, be modified so as to make it easy for a teacher to tell when the air has become too impure to be healthful. Probably most of the gentlemen present are familiar with the method. It is to have several bottles. one containing, say, 100 cubic centimetres, another 200, and another 300, and a saturated lime-water solution. The bottles being filled with water, commence with the smallest bottle and carefully empty the water, introduce the standard quantity of lime water, say 15 cubic centimetres, and shake the bottle. The purpose of pouring the water out is to bring into the bottle some of the air which is in the room. If the water becomes turbid the quantity of carbonic acid gas is easily determinable from the relative proportion of the lime-water and the air in the bottle.* If it is not indicated by the first bottle, the next larger quantity may be used, and so on until you find what quantity of air does render the lime-water turbid. After the standard of the room has been determined a bottle of that size should be kept on hand, filled with water, and if the teacher thought that the air was becoming impure, he could simply pour out the water introduce the lime-water, and shake it, to test the degree of impurity relative to the standard.

PROF. S. H. WOODBRIDGE.—I would like to say that there has been an instrument lately devised by Prof. Wolpert for the indication of atmospheric vitiation, or perhaps, I should rather say, for indicating the proportion of carbonic acid in the air, which may take a place, for that purpose, with the thermometer for the indication of temperature, and the barometer for the measurement of atmospheric pressure.

It is essentially this: A shallow glass vessel about 6″ in diameter and 2″ deep is partly filled with a standard solution of carbonate of soda, colored a bright carmine by phenol-phalin in solution. On the surface of this liquid floats an air-tight metallic box, which may be contracted or enlarged within narrow limits by a conveniently placed thumb-screw. To the edge of this is attached a glass siphon tube, one leg of which is immersed in the liquid, and the other end drawn down to a much smaller calibre, overhangs the edge of the glass vessel. The rate of flow through this siphon is regulated by the distance by which its outside end is below

* With 100 cu. cm., 6 parts in 1,000; 200 cu. cm., 12 parts; 300 cu. cm., 8 parts; 450 cu. cm., 6 parts.—Billings. P. 22.

the level of the liquid in the vessel, and this is in turn regulated by the bouyancy of the float. The liquid drops from the siphon into an angular trough, inclined and open at its lower end, and having suspended from its tip a small sized cotton string of some 15″ length, in such fashion that the liquid will follow down the cord, coloring the string a bright carmine. The string is weighted at the lower end by a glass ball, and the drip is caught in a small receiving vessel.

If carbonic acid is present in the air, it combines with the carbonate of soda, and forms a bi-carbonate, and in this solution the coloring disappears. The greater the proportion of carbonic acid present in the air, the less the time of the exposure must be to change the carbonate to a bicarbonate, and the shorter the length of the carmine colored string. Behind the string is a scale showing the points at which the coloring should disappear for certain proportions of carbonic acid in the air. The discoloration is not sharply marked, but sufficiently well for a trained eye to fix the point to within a fraction of one part of carbonic acid in ten thousand of air.

The carbonate solution must be renewed as often as once a month, and the string renewed or washed frequently enough to keep it clean.

PROF. WM. WATSON.—I would like to enquire how sensitive it is?

PROF. WOODBRIDGE.—It indicates changes very quickly. The results obtained by this apparatus give results closely approximating those obtained by the Pettenkoffer method. The greatest source of error is in judging the point of discoloration by the eye.

MR. MCCLINTOCK.—I think that perhaps another answer to Mr. Smith's question might be this: The amount of air admitted into a room should never be left to the discretion of either the teacher or the janitor; it should be made absolute. The degree of temperature at which it is admitted may, of course, be left to the teacher; but the amount of air, it seems to me, never should be; that is, the amount of air coming into the room should be through a certain sized aperture, based on the number of pupils that there are in the room, and the amount required per pupil per minute. The only opportunity of regulating it that should be left to the teacher should be in regard to whether the temperature should be 68 or 70 or 72.

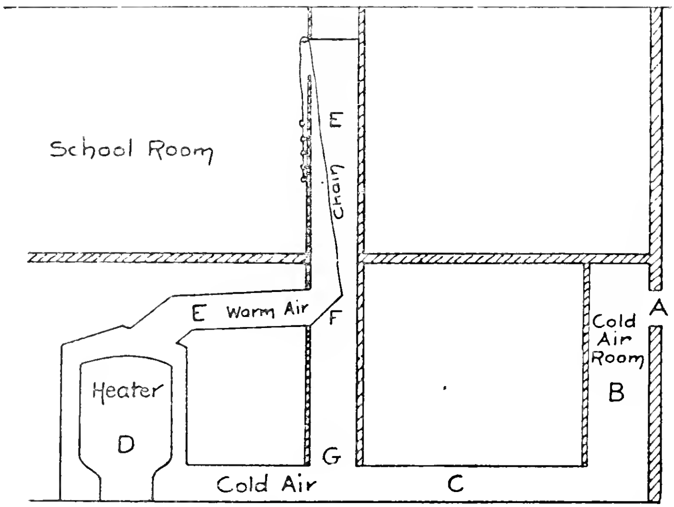
THE PRESIDENT.—While the scholars are there?

MR. MCCLINTOCK.—Based on the amount of air used while the scholars are in the room. My experience, from what I have seen, is that the working of one of these quiet and apparently inactive systems such as we looked at to-day, is not observed by the teachers. They come into the room, after climbing up two or three flights of stairs, and remark "Phew! this is close!" and up go the windows, and the result is that the whole effect of the ventilating system is spoiled, because the teachers do not distinguish between the temperature and the purity of the atmosphere. I think that the more completely this method is taken out of the hands of teachers and janitors the better it will be for the scholars.

THE PRESIDENT.—Who is to regulate the time for setting the steam on if not the teachers?

MR. MCCLINTOCK.—Why, we will say that the system is in operation

before the school is opened in the morning, so that the air in the room is pure and at a temperature of 70. Now, that air, as we observed to-day, comes from the outside, and becomes warm. If it is too warm the teacher simply turns the valve and shuts off the steam. I do not know whether they all fully understand that or not. In the sketch—*A* is the opening into the side of the building, where the cold air comes into a chamber *B*, leading out of the bottom of chamber *B* is a flue *C*; *D* is the heating apparatus, of whatever shape it may be desirable to have it, where the air is heated. The flues for warm air into the different rooms are, we will say, at *E*-*E*, so that the air passes up into different rooms. The air comes in from the outside, envelopes the heater, and becomes warm; then it passes up one of these flues *E* at a temperature sufficient to warm the building. At *F* we have a damper connected with the school room, so as to be worked by the teacher by means of a chain passing over a pulley. In the



first place, this flue goes to the bottom, and has an opening *G*, so that the bottom of this is always full of cold air. When the damper *F* in the flue back of the heater, is raised, the air, unwarmed, passes directly up the flue into the building. If you turn that damper down across the flue, then the air passes over the heater and becomes warm, and passes up at whatever temperature it may be raised to by reason of its coming in contact with the heater. Then if it is desired on the part of the teacher to change the temperature at all by working this damper, one way or the other, the cold and warm air are so mingled as to enter the room at the required temperature. This is the only feature needed by either the Smead or Fuller & Warren system. In the Smead system it is managed by the teacher, and in the Fuller & Warren system it is managed by the teacher and the janitor; in other words, the janitor can tell at the furnace whether the cold air is passing into the room or the warm air, or what proportion of cold or warm air is passing into the room, whether a half or a quarter.

There is nothing in either of the systems that leaves the matter of the purity of the air to the discretion of the teacher.

MR. HENRY MANLEY.—Before school in the morning, and after the fire is started it is being ventilated and the air changed at the same rate as afterwards?

MR. McCLINTOCK.—Exactly.

MR. MANLEY.—And you are using up fuel to do it right through the day?

MR. McCLINTOCK.—In the Fuller & Warren system there is a peculiar by-pass or double damper so arranged that the fresh air passing into the heater can be shut off, while at the same time the warm air from the rooms is again passed under the heater and thence into the school room again. The real trouble with it is that the janitor may sometimes omit to shut it off in the morning, –that is, he may be too lazy to do so, and not attend to his fires. in which case there would be, as has been described by the "Sanitary Engineer," a nasty ventilation.

THE PRESIDENT.—There was one peculiar portion of this system which we saw this afternoon, which was referred to in the paper which has been read, and which I wish might be fully impressed on the minds of those who were not with us. I refer to the sanitary condition of the schoolhouses, which has no connection with the air at all,—the drying up of the excrement. I wish that in this discussion the good and the bad features of that system might be brought out before we proceed to another paper.

MR. McCLINTOCK.—I would like to say, Mr. President, that although the matter was talked of this afternoon, this part of the system is something that ought to be discussed more than any other part of the Smead system, as applied to the schools. The germ theory seems to have taken a pretty strong hold here as well as in Germany, where it has been very thoroughly considered. I think that it is understood that the disease germ or bacteria, or whatever name we may designate it by, cannot be received into the system if the air is in a particularly humid state, or if the fœcal matter that is contaminated with these bacteria is immersed in water instead of being exposed to the dry air. There are some species of bacteria that, if they get to the lungs, create, as I understand, tuberculosis, and there are others that, if they get into the intestines, produce other diseases, perhaps cholera or typhoid or kindred diseases.

Now, the question has been raised by some of our doctors in Chelsea as to whether there is a possibility of these disease germs being carried out on the strong current of air passing over the fœcal matter in the process of consumption by heat, and being taken up the flues into the open air and thus disseminated about the building. Of course if we can bring these bacteria under certain heat influences, something less than 200°, there is no doubt that that would kill them absolutely. Now, it seems to me that the question with regard to the application of this system to school buildings is whether we shall have the fœcal matter dropped into latrines instead of into a dry pit, allowing the same air that ventilates it now to ventilate it then, but removing the possibility of the bacteria being carried up the flue by means of the dry air, these latrines being emptied

into the sewers once a week or once a fortnight, or at such times as it may be deemed necessary; or, at certain stated times, even as often as once a day if it be found necessary. If the dry pit is used the whole of the dry fœcal matter to be saturated with oil and burnt, every day if necessary, thus destroying all the bacteria or other injurious substances. I think that this last method could be applied without any perceptible nuisance to the neighborhood, and that that would be the end of it. It seems to me that it is a subject well worthy of discussion. If anything can be brought out to show that the system is bad, we would like to know it.

THE PRESIDENT.—What astonished me was to see how thoroughly it was being carried out in the school houses which we visited this afternoon, where there are some 900 children, there being no cost except that of fire in the flue; is that not true?

MR. MCCLINTOCK.—That is true. There is no cost at all except the cost of the fire in the flue. In fact, if those vaults ran for a year there would not be in them a barrel and a half of fœcal matter from 450 pupils.

THE PRESIDENT.—And as we stood by the urinals, which had not been cleansed for a year, there was no offensive odor at all about them that was perceptible. We saw that they were there, otherwise we should not have known of their presence.

MR. F. P. STEARNS.—I have not heard how this system is arranged in the summer. Is the fire or heat kept in the flues in the summer? If it is not, I would like to inquire what the arrangements are for that season of the year.

MR. MCCLINTOCK.—It is not mentioned in my paper; the heater in the base of stack has the power that produces the current in the upper stack, and this is separated entirely from the heating apparatus of the building, and it can be worked with about two tons of coal, I think, for a year; and by keeping that going, the whole system works just as well through the summer as it does in the winter.

MR. FREDERICK TUDOR.—I should like to say, with regard to the drying up of the fœcal matter, that if that amount were deposited in the privies, where it remained sodden and fermenting, I do not think that the community, or even the physicians, would think about it at all, but I do not see why it would not be a great deal more dangerous. All those privies and backyards have very small flues and this foul air would be disseminated in many directions, whereas, in the employment in this system there is an abundance of air to swamp and drown all offensive odors and matter. And, after all, the extent of the contamination is very trifling when you consider the quantity of air passing over the fœcal matter. I do not think that the air passing from the fœcal matter in this process could bear more than a very slight taint; I have never smelt it, but that is my impression; I do not think that it would smell half as bad as a common privy.

THE PRESIDENT.—The question is, if the whole of the Back Bay had such a system would the air be pleasant to breathe?

MR. TUDOR.—Think of all the soil pipes that there are about now! I think that if this system were adopted the air would be very much purer than it is now.

MR. L. M. HASTINGS.—There is one matter that I did not understand

n dealing with this subject, and that is the relative proportions of carbonic acid gas in the two systems, the Smead and the Fuller & Warren. In one case it is 16 and a fraction per cent. and in the other case it was something like 9. I could not understand the difference in the result. Can Mr. McClintock account for the difference between the results of the tests?

Mr. McClintock.—I am very glad that the question has been suggested. The adoption of the Smead system came early in 1888, before our committees were fairly satisfied as to the quantity of air per pupil per minute that was necessary, and the building of the school was planned so as to give 20 cubic feet per minute. I think that I mentioned in my paper that with the velocity we get on the extracting flue we received practically that amount. and the corresponding amount of carbonic acid gas in the air was the result of contamination. In other words, we did not take enough of the impure air out to allow a sufficient quantity of the fresh air to flow in, so as to reduce the percentage of carbonic acid gas to the ratio recommended as being within the limit of safety in the Shurtleff school, whereas the Carter school is designed to carry the necessary quantity of air, and it does reduce the quantity of carbonic acid gas to the proportion required. That explains the difference between the two systems.

Mr. Manley.—There is one other matter that occurs to me. There are two things which seem to have been attended to in relation to the air admitted for breathing purposes into these school houses, its temperature and its comparative freedom from carbonic acid gas. But there is one other item, perhaps, worthy of consideration. and that is the question of humidity. I would like to inquire if that has been attended to. I know that we all have evaporating pans connected with our furnaces, and that we will use them for all that they are worth, but I do not know whether they do any good or not. I should be glad to receive some light on this subject.

The President.—I am very glad that the matter has been brought up. It is something which has occurred to me a number of times to-day.

Mr. McClintock.—As far as those two buildings are concerned there has been no allowance made for an increase in the humidity of the air after it passes into the building. The principle seems to have been to introduce the air into the building at a low temperature. At the same time, I imagine that a large portion of the moisture may be taken out. If so, that may be a weak point.

Mr. Tudor.—But it is not a fact that the heat drives away the moisture.

Mr. Manley.—Its capacity for moisture is much greater.

Mr. Tudor.—It is a great mistake to say that the heating apparatus drives away the moisture.

Mr Manley.—Is that not the practical result?

Mr. Tudor.—No; that is not true.

Mr. Manley.—It has the effect of drying other substances.

Mr. Tudor.—The capacity of the air for moisture is increased by raising the temperature; that is all. The same weight of water per pound of air is there that was there before.

Mr. Manley.—If a washerwoman wanted to dry clothes she could dry them much more quickly in hot air than in cold air having the same amount of moisture.

Mr. Frederick Brooks.—I was taught years ago that it was more important for health that the air of our houses should have a proper moisture than a proper temperature. I do not believe that, although I do not pretend to have mastered the subject. It is well known that physicians send patients to such places as Minnesota and Colorado for the sake of the dry climate. I myself decidedly prefer a dry climate. On the other hand, it is notorious that a moist climate, for instance, such as is necessarily found at sea, is sometimes favorable to health. I do not think that the one or the other is essential to health.

Mr. Tudor.—I would like to say a word about the dryness of climate. I have an impression that that really means a climate where there is a very light rainfall, and not that the atmosphere is not at times almost saturated with moisture. I know that in the spring our east winds are held to be very moist, for example. Now, such is not the fact. The east winds which we have here in June, and which are so disagreeable, are extremely dry, and yet it is called a damp atmosphere.

Mr. Manley.—I would like to inquire of the experts present if they have given up the theory and say that in their work the question of humidity is not an important consideration.

Mr. Tudor.—I, for one, think that that is very important. I know that in my own work I have always provided for plenty of moisture. I think that we do right to follow nature as far as we can.

The President.—It seems to me that, as the time is passing rapidly, unless there are other observations that some of the gentlemen desire to make with reference to this paper it would be well to pass on to the next subject.

Mr. Tudor.—I wish that the subject of the privies at Chelsea might be discussed a little more fully. I am very much interested in that matter, and it does not seem to me to have been quite settled.

Mr. George F. Loring.—It seems to me that the system at the Shurtleff school is very well adapted to the requirements of either country school houses or city school houses, if all the fecal matter, as well as the urine, is connected with a sewer, as was the case at the Shurtleff school which we saw this afternoon.

The President.—I think you are mistaken there.

Mr. McClintock.—Yes; you are mistaken.

Mr. Loring.—At any rate, the proper method is to deposit the urine and excrement and remove them into the sewer, so as not to contaminate the atmosphere in the vicinity of the school house, or, at least, to take no unnecessary chances of doing so; and if you want to ventilate your building you can do it by the Smead system, which I think superior to the Fuller & Warren system.

Mr. F. B. Knapp.—I have looked somewhat into this question of sewage and fecal matter, and it seems to me that this drying-up method is the best of anything that I have seen with the exception, perhaps, of a thorough system of water closets, each water closet being thoroughly ven-

tilated and carrying the excrement off immediately. I have never had brought to my attention any system of collecting and getting rid of once a day, or once a week, or at frequent intervals, that it seemed to me at all compared with this; and I have in mind all the systems that I have seen. But I think that the separate system of a good hopper water closet, well ventilated, is superior to this.

MR. McCLINTOCK.—Mr. President, I do not wish to occupy all of the time in this discussion this evening, but I desire to say that I have had charge of from twenty-five to thirty miles of sewers during the last ten years, and I know how nasty a thing a sewer is, and I know how hard it is to keep it clean; and if there is any known method by which the sewage can, with greater ease and simplicity and a smaller cost, be disposed of than by means of this system, I should be heart and hand in favor of its adoption.

Now, certain experiments have been made by the State Board of Health at Lawrence, which shows that bacteria are susceptible of a very high state of cultivation. I believe that they have experimented on a certain, small, number in a sewer and obtained enormous results—I do not dare to attempt to give the figures. Mr. Stearns will help me out on that. Those are exactly the conditions which we have in the sewers. At the same time that Board tells us in the next breath that sewage can be purified of bacteria, and also that after the sewage matter passes through a filter bed constructed in a certain way the bacteria almost entirely disappear. The few that go through the filter bed pass off in the water, and if the water has not in it the substance on which they feed they die.

Now, I am satisfied that to-day our older sewers must be alive with bacteria, if they exist in sewers at all, and there can be no doubt that they do. I cannot see why this system is not a clean way of getting rid of a nuisance, whether we put it into a common sewer or whether we dig a big metropolitan sewer, or whether the residuum of the fæcal matter be burnt after being saturated with oil.

THE PRESIDENT.—Certainly no one could examine that system and see it in operation without being convinced that that is practically being carried out to-day on a very considerable scale and at a very slight cost. I would like to inquire if it would be possible to extend that system by uniting quite a number of buildings and having a large flue connecting several houses? Why not have a flue of large area and have a fire constantly burning under competent supervision and connect quite a number of houses in that way, making it one continuous process.

MR. McCLINTOCK.—I do not see why it is not competent to take a number of houses and arrange the matter in that manner. I certainly would rather run my chances that way than with the water system, where the seals of the traps are constantly being broken, and with the inflow of foul air from the sewers. I think that, in a previous paper, I endeavored to show that the circulation of air in the sewers is very important; it may flow one way or the other.

MR. SMITH.—Do you think that the exclusion of the fæcal matter from the sewers would materially improve their condition so long as sinks are connected with them?

MR. McCLINTOCK.—I would be willing to go farther and evaporate

everything, if it is possible to do so, and thus do away entirely with sewers.

MR. LORING.—It seems to me that the Fuller & Warren system is weak. If there is foul air to pass off after the excrement has been dried up, then what remains of the fæcal matter should be burnt by a small furnace. If the foul air can be purified of all odor and the bacteria consumed, by the same furnace which heats the shaft, at the same time giving a draft in the chimney, then it seems to me that the whole process will have been solved.

THE PRESIDENT.—As I understand it that is just what Mr. McClintock proposes to do.

MR. MCCLINTOCK.—Exactly; to burn up the fœcal matter and destroy the bacteria,—not to let one of them escape!

MR. LORING.—In regard to the matter of humidity, it seems to me that there could be some way of arranging the water so as to supply an equal amount of moisture to each room, this can be done in the hot air shafts, and that is practically what we want to accomplish.

THE PRESIDENT.—Who was it that wanted to see this question settled? (Laughter).

MR. MANLEY.—There is one other little point that occurs to me. We have heard both sides of this matter to-night. Some people say that the sense of smell is a sufficient test of the purity of the air, and others say it is not sufficient. It seems to me that the sense of smell is an uncertain test. For instance, the air may be reasonably pure in this room (laughter), and it doubtless is, if judged by the perception of us who have been here for two or three hours, and have gradually become seasoned to it, as it has grown less pure; but I am inclined to think that if a person came in here now, after having been out in the fresh air, his sense of smell would indicate to him that this air is not particularly sweet (laughter); and so, as we all know, if we go into a sewer, the odor is at first very offensive, but after having been in there a short time we become seasoned to it, and do not notice the odors at all. During an address which I once heard before an agricultural society, the speaker, to illustrate the point that odors given off by manures do not necessarily reduce their fertilizing properties, said that a dead cat could be smelt over four acres of land. (Laughter). The point I wish to make is that unpleasant odors do not necessarily mean unwholesome air.

THE PRESIDENT.—We have two or three more interesting papers to listen to, and while we might keep discussing this matter all the evening, yet it seems to me desirable that we should now pass to the next item in our programme; and, unless the Society wish otherwise, I will now call upon Mr. Perkins, of Lynn, to read his paper on heating and ventilation. He is thoroughly informed on the subject, and I will now ask him to entertain you by reading the paper which he has prepared on that subject.

BY THEODORE P. PERKINS.

It is the purpose of this paper briefly to describe what has been done in Lynn during the last five years, in ventilating several primary and

grammar school buildings, under the general direction of Dr. J. G. Pinkham of the school board.

The writer derives his knowledge of the facts from having been a "yearling" member of the Lynn School Board, (in 1885), and from having furnished more or less advice and designs for all the improvements here mentioned.

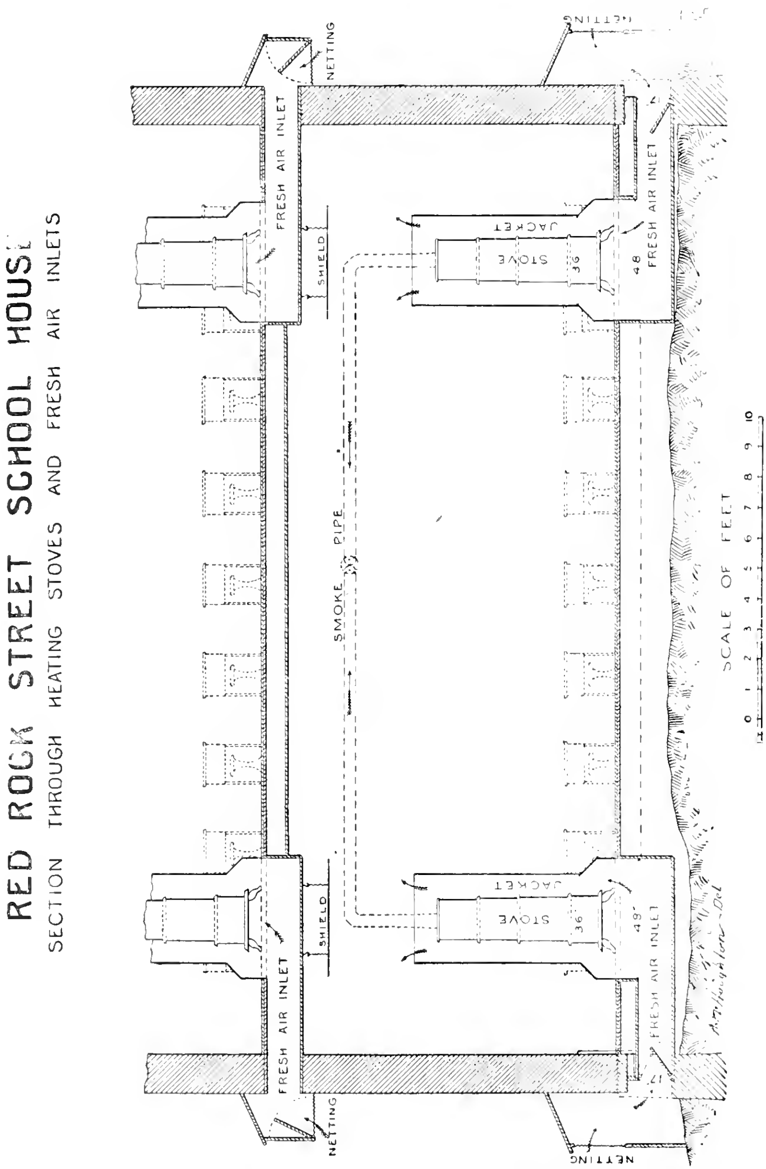
In the year 1883, a special committee reported to the School Board on the sanitary condition of the school-houses of Lynn, noting particularly the apparatus, or lack of apparatus, for air supply and removal. This committee took air-meter measurements in many buildings; also samples of air, which were tested for carbonic acid. The facts brought out in their report led the School Board, the next year, to make up a new standing committee called the "Committee on Sanitation." Of this committee Dr. Pinkham was chairman, and some new work of ventilation has been done under it every year since.

The Chase avenue school-house in West Lynn was the first. This wooden building, although modern, and well built, had no efficient airing appliances, and chemical analysis of its air, when in use, showed $\frac{29}{10000}$ of carbonic acid, a greater proportion than in any other building examined. This fact, and the testimony of the noses of persons interested pointed to dangerous organic contamination, and alterations were resolved upon, following the general method described by A. C. Martin, architect, in the report of the Massachusetts State Board of Health for 1871.

The old chimney in the rear wall was torn down, and a new one built in its place, with two plain flues in it, each two feet square, the chimney being covered with a galvanized-iron cap. These outlet flues were connected, by rectangular openings at the levels of the respective floors, with platforms about eight inches high, two in each room, running from the chimney each way along the rear wall, then turning and running along the side walls toward the front.

One of these platform ducts in each room was cut off by the chimney from direct connection with its proper flue, and connection was made by boxing around the chimney. Twelve rectangular holes in the edges of the platforms, obstructed by iron registers, connected them with each room.

Fresh warm air was supplied through jacketed stoves. The stoves were of the "pyramid" style, about 6½ feet high, 18″ in diameter at the base and about 15″ at the top. Each was encircled by a "jacket" or cylinder of galvanized sheet iron, 3 feet in diameter, resting on the floor, and open at the top, the front being cut into for access to the stove doors. The floor-boards were cut away inside the jacket, the stove being supported on special strips, and a cold air duct was built, starting from the space under the jacket and running horizontally through the side wall of the building, to the outer air, the outside opening being protected by a hood and wire netting and provided with hinged flaps or valves for shutting the air-box when not in use. The stoves were placed near the front of the room, in each case, and within a few feet of the side wall, so that the cold-air ducts were short. These ducts were supposed to be large enough to give a full supply of air when only one stove, (and therefore only one inlet), was in



use in each room. The smoke-pipes in each room were united, and run up through the middle of the chimney flue for that room and through the top of the cap, ending above everything else.

The writer's attention was first called to this apparatus in January, 1885, when it had been in use some weeks.

The Committee, seeing that the heat from the stove pipes did not move as much air as was desired, had broken through the *with* or partition between flues, at the base, and put in a kerosene stove to heat both flues, but this device was not working well. A current of air was observed to blow horizontally across the stove, causing the flames to flare, and sometimes to go out, thus adding kerosene fumes to the other malodroous substances in the school-rooms. This air-current was accounted for by the peculiar construction of the chimney-cap, which resembled in general appearance a bird-house, having a pitch roof and metal slats on four sides. It was divided by an upright partition, which was virtually a prolongation of the with of the chimney. The wind blowing against this partition was deflected down one flue, and, to get out, had to go up the other flue or into the school room. It did both, usually.

The upright partition was removed and the blind-slats changed to admit air more freely, but other things remained to be done. The inlets from the platforms into the chimney were, as aforesaid, at the levels of the respective floors, one of them being about 5 feet and the other about 16 feet above the point where most of the heat was applied. There being no chance for air to get in below this point (for the door from the cellar into the chimney was kept closed) it followed that most of the school-room air must go down before it could go up—in other words, there must be in the lower part of each flue two currents, one upward and one downward, or else there must be a downward current in one flue and an upward current in the other, the result in either case being to take away about half the efficiency of the apparatus. This was changed—the high inlets were stopped; all air was carried through 28-inch tin pipes (one of them running through the lower school room) to the very bottom of the chimney. The oil stove was abandoned, and a small "ring cylinder" cast-iron coal stove was set in the with of the chimney, a foot or two above the point where the foul air entered, the two flues being wholly separated by the stove and brickwork. Again tests were applied, but the draught was still too feeble. Search was made, and it was found that the spreading bases of the large stoves blocked up a large part of the air space in the lower parts of the jackets. Then the bases of the jackets were made flaring, to allow as much air space at those points as in other parts of the air channels, and the fresh air inlets for the lower room were enlarged. Air-meter tests taken just after these changes were made indicated the passage of about 40,000 cubic feet per hour through the lower room, the temperature out of doors being 15° to 20° F., and in the school room 63° to 66° F. The draft in the upper room was a little less, probably on account of the small size of the fresh-air inlet and increased length and friction in the outlets.

Experience at this building prepared the way for other like enterprises. Three other two-room primary buildings have since been ventilated on the same general plan; their apparatus differs from that just described in the following particulars:

At the Red Rock St. school-house, in 1886, the chimney flues were built large enough to have 4 square ft. of clear sectional area in each, after deducting the obstruction caused by the smoke-pipes, which were of fireclay, and set in the corners. No cellar was under the rear of this build-

ing, hence the flue-heating stove was set above the first floor level. and the foul air came into the chimney just below it.

Experiments at the Chase Avenue building had proved that most of the air was drawn through the platform-holes nearest the chimney; therefore no side-platforms were built at Red Rock St., and large openings were made through the brickwork, leading directly from the lower room into the chimney. The foul air from the upper room was carried down through the lower room to the base of the chimney by a 30-inch circular tin pipe. The bases of the jacket were somewhat improved in shape, with perhaps a slight gain in effectiveness. Instead of registers, coarse wire netting, about equal to one inch square mesh, was stretched across all outlet openings. and two wooden slides in each room shut off all the outlets when not in use. The fire-clay smoke-pipes in the chimney stopped on a level with the top of the brickwork, and a rectangular cap of the "Emerson" type covered the whole.

Air-meter measurements have been taken in this building, in 1886, '87 and '88, and some samples of air collected and analyzed, with the following results:—

LOWER ROOM.

Out-door temperature. (Fah.)	Temperature in school-room.	Difference.	Velocity at largest outlet ft. per sec.	Indicated discharge from room, cu. ft. per hour.	Number of scholars present.	Proportion of CO_2 in air just before end of session.
47°	6[illegible]°	21°	4	58560	..	....
3[illegible]°	68°	3[illegible]°	4.8	1[illegible]332[illegible]	..	....
[illegible]5°	[illegible]7[illegible]	32°	6.3	105[illegible]0	..	....
35°	6[illegible]°	33°	5.7	93360	..	....
29° to 34°	63° to 72°	36°	6.7 to 7.3	113000 to 123000	56	.000482
27°	66° to 7[illegible]°	41°	6.7	107600	..	....
17° to 21°	64° to 76°	51°	7.2 to 8.5	113000 to 143000	57	.000614

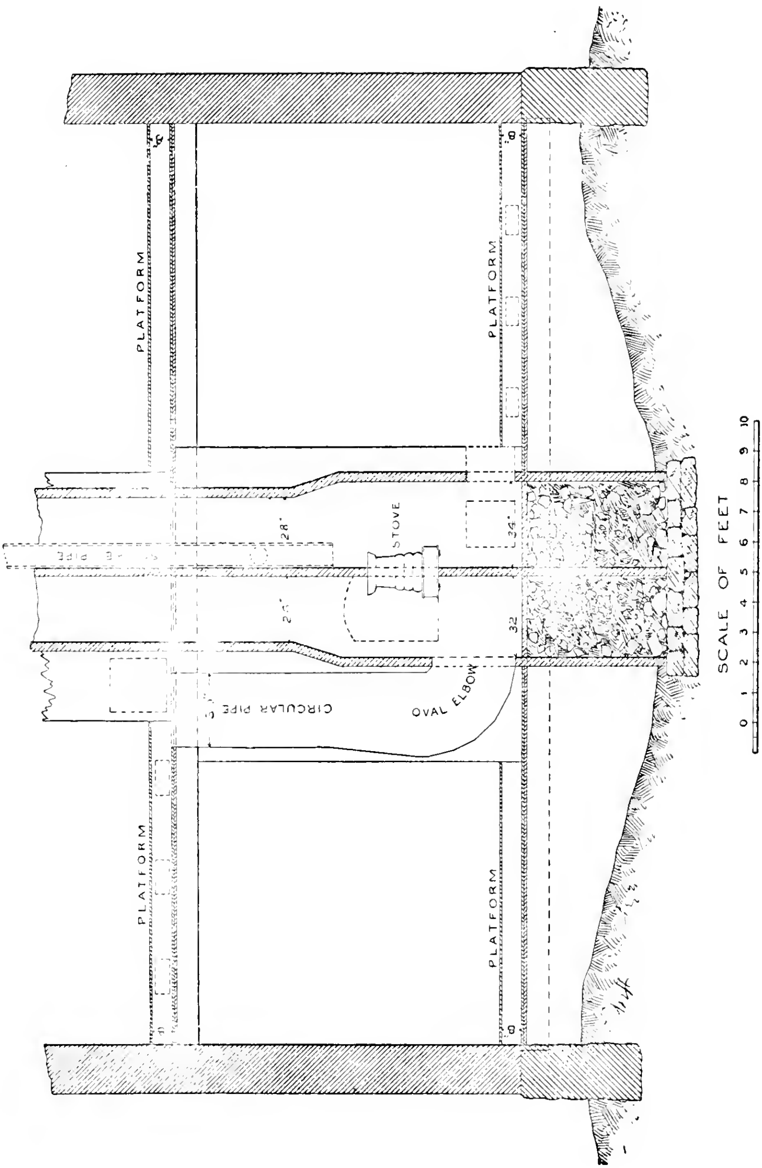
UPPER ROOM.

3[illegible]°	61°	26°	4.7	75060	..	....
[illegible]5°	68°	33°	5.2	83400	..	....
36°	66° to 73°	33°	5.5	90000	53	.000746

The difference of temperature between the air at the floor-level and that at the breathing-line, (3 ft. above floor) ranged from two to seven degrees with outside temperatures 16° to 35°. The building is of brick, and warm. All who have to do with this school-house pronounce the air to be of exceptional purity. The task of looking after the fires, to keep the temperature of the room even, is, of course, only one of very many others imposed upon the teacher, and in practice, the temperature varies, at times, considerably from the normal of 68° Fah., being usually too high.

At the Baltimore St. (old) school-house, in 1887, the air-supplying and air-removing appliances were placed in the same end of the room, following the suggestion of Warren R. Briggs, architect, who states as the result of experiments with models that this plan secures more thorough diffusion of the air. In the upper room, two small jackets were built, one

on each side of the new chimney, the cold air being taken just above the projecting base of each stove. In the lower room: a double jacket was built, containing two stoves, one or both of which might be fired at pleasure. Separate smoke-pipes inside the chimney were dispensed with, the smoke being discharged directly into the large exhaust flues, (each



RED ROCK STREET SCHOOL HOUSE

SECTION THROUGH CHIMNEY ON LINE PARALLEL TO REAR WALL

about 2 feet square.) No inconvenience from this arrangement was ever reported.

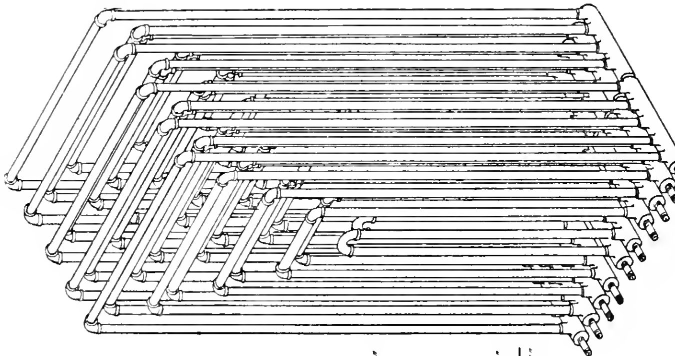
The fullest opportunity to test the peculiar features of this building was not granted, as the Board of Aldermen, in its wisdom, saw fit to build a four-room school-house on this site the following summer—for, in our town, the Board of Aldermen builds the school-houses and the School Board alters them over, this latter building being no exception. The ventilating apparatus of the old building was removed to the Jackson St. building, and worked over into a new one. Some few innovations were adopted here. For lack of space, the two stoves with their jackets were set close together in one of the front corners of each room, and there was for each room only one foul-air outlet into the chimney; protected by 3-inch iron gratings instead of wire netting. The smoke-pipes were run straight from the stoves to the chimney, disregarding the unwritten law which says that they must run level, and parallel to the walls of the room. The fresh-air inlet ducts for the lower room were connected, making a continuous pipe, nearly straight, from one side of the building to the other. For the upper room, the duct turned at right angles, and there was an opening in the front wall, and another in the side wall.

The same committee has also undertaken improvements of this nature in longer buildings heated by steam. In 1885, the Ingalls school-house, on Essex St. was taken in hand, but the alterations were not radical enough to bring it up to a proper standard, although there was some improvement. The building is almost the exact counterpart of the Shurtleff school in South Boston, containing fourteen rooms and a large hall. The old wooden outlet ducts were left in place, but each group of them was capped with a circular Emerson ventilator—rectangular ones would have been better. Eight of these were on the main portion of the roof, which was rather flat, with a large square cupola in the middle, and the other two were on a tower, in front, and were several feet above all the others. Measurements at the room-outlets connecting with these two ventilating-caps showed a much stronger draft in these than in the others, in high winds—in some cases, even, the strong draft in one of these caused a reflux in one of the others, both being connected with the same room. Several other minor improvements were made, such as substituting coarse for fine wire netting, etc. Measurements at this building showed as the result of removing a wooden frame strung with ⅝ inch wire netting from each of several foul-air outlets, a gain of 25 to 30 per cent in discharge, which was nearly in proportion to the area gained by the change. This shows how easy it is to make air-moving appliances inoperative by neglecting a few small details. An air-channel is practically only a little larger than its smallest part. Yet the writer has lately seen small outlet openings in a school-room covered with two screens each—a half-inch mesh inside and a *sixteenth-inch* mesh outside—the two nettings being about one-half inch apart. If fine wire nettings must be used, the size of the openings should be greatly increased. But coarse gratings, especially if they are easily removable, are probably far better.

At the Sanborn school house, in 1888, a more thorough work was undertaken. A minimum supply of sixty thousand cubic feet per hour for

NEW COILS FOR WARMING FRESH AIR.

Baltimore Street Building. [Sanborn School coils were also of this pattern.]



Isometric View of Coil.

Bill of Pipe (1¼) and Fittings for this Coil.

Uprights.

10	pieces,	each 5'-10" long,	.... 58'-4"		
8	"	" 5'-6" "	44'-0"		
10	"	" 5'-2" "	51'-8"		
8	"	" 4'-10" "	38'-8"		
10	"	" 4'-6" "	45'-0"		
8	"	" 4'-2" "	33'-4"		
10	"	" 3'-10" "	38'-4"		
8	"	" 3'-6" "	28'-0"		
10	"	" 3'-2" "	31'-8"		
8	"	" 2'-10" "	22'-8"	391'-8"	

Horizontals.

9	pieces,	each 2'-4" long,	21'-0"	
9	"	" 1'-10" "	16'-6"	
9	"	" 1'-3" "	11'-3"	
9	"	" 0'-8" "	6'-0"	54'-9"

Total no. of linear feet of straight pipe, ... 446'-5"

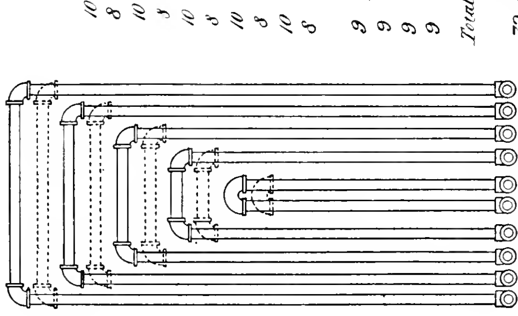
Fittings.

72 elbows, (36 right hand, and 36 right and left.)

9 return bends, open pattern.

10 nine-branch tees, in one piece or two pieces each.

Total no. sq. ft. heating surface in this coil, about 219.



End Elevation of Coil, showing first row of pipes by full lines, and horizontal pipes and elbows in second row by dotted lines.

each of the eight school rooms, containing upwards of fifty scholars, was taken as a standard.

A "Clogston" heating boiler was put in, with about 3,000 linear feet of $1\frac{1}{4}$-inch steam pipe, in addition to the boiler and "direct" heating plant already there. A sheet-iron air chamber, in shape resembling a triangle, was put in at each corner of the basement, each chamber drawing its air supply from two windows on two different walls of the building, each opening being covered with a coarse and strong wire grating and provided with doors and a valve. Two upright sheet-iron ducts rose from each of these corner air chambers, each duct containing a coil of 320 linear feet of $1\frac{1}{4}$-inch steam pipe. These coils were each made of two sets of branch tees, one set "feed" and one "return," connected by upright and horizontal pipes and elbows, outside pipes long and inside pipes short, several "nests" of pipe, in fact, one fitting inside another; the uprights from each branch tee being alternately short and long in order that the horizontal pipes might offer little obstructive area to the upward air current. For a lower room the coil was compact and the duct large in cross-section, for the vertical space was only about 7 feet, but for an upper room the coil was about 10 feet long, with the pipes fewer and further apart. The duct for an upper room ran up through the lower room and was boxed in. All ducts ran up full size, each to a point about 6 feet above its school room floor and were open at the top.

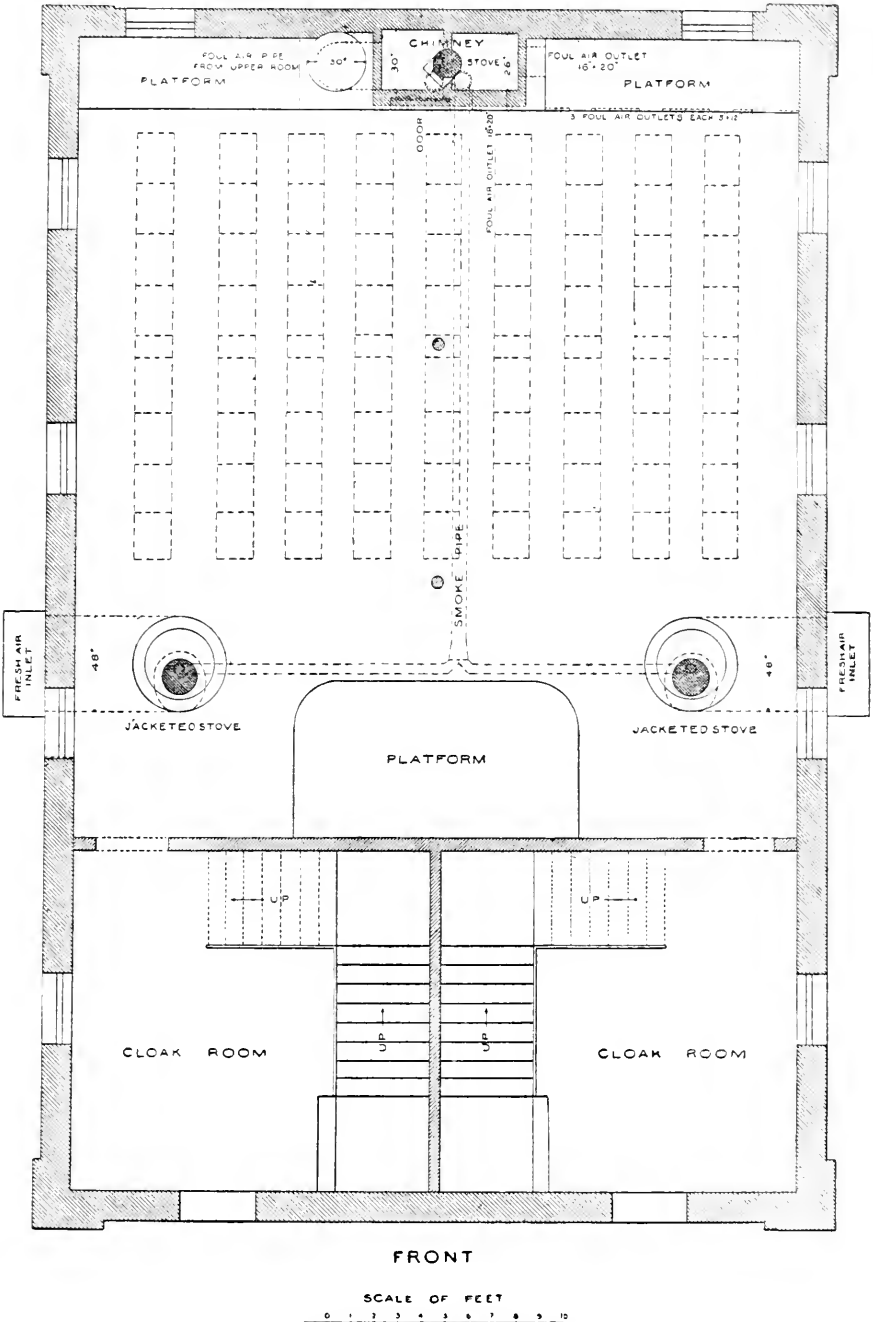
For removing the foul air rectangular sheet-iron ducts, each 2 feet square, were used, each starting at the floor level of the room served by it in the cloak-room, and running up as straight as possible to the attic. Each duct had in it a large opening for the school room and a small one for the cloak-room, the combined sectional area of these two openings being somewhat greater than that of the duct itself, the openings being coarsely grated, as usual. These ducts ran up in pairs from the second floor to the attic, and were there joined into one large pipe, 4x8 feet, ending in a rectangular Emerson cap of the same size provided with a damper. The opening from the rooms and the inlet ducts were also provided with dampers or doors, and from 45 to 70 linear feet of $1\frac{1}{4}$-inch steam pipe was placed in each outlet duct to move the air.

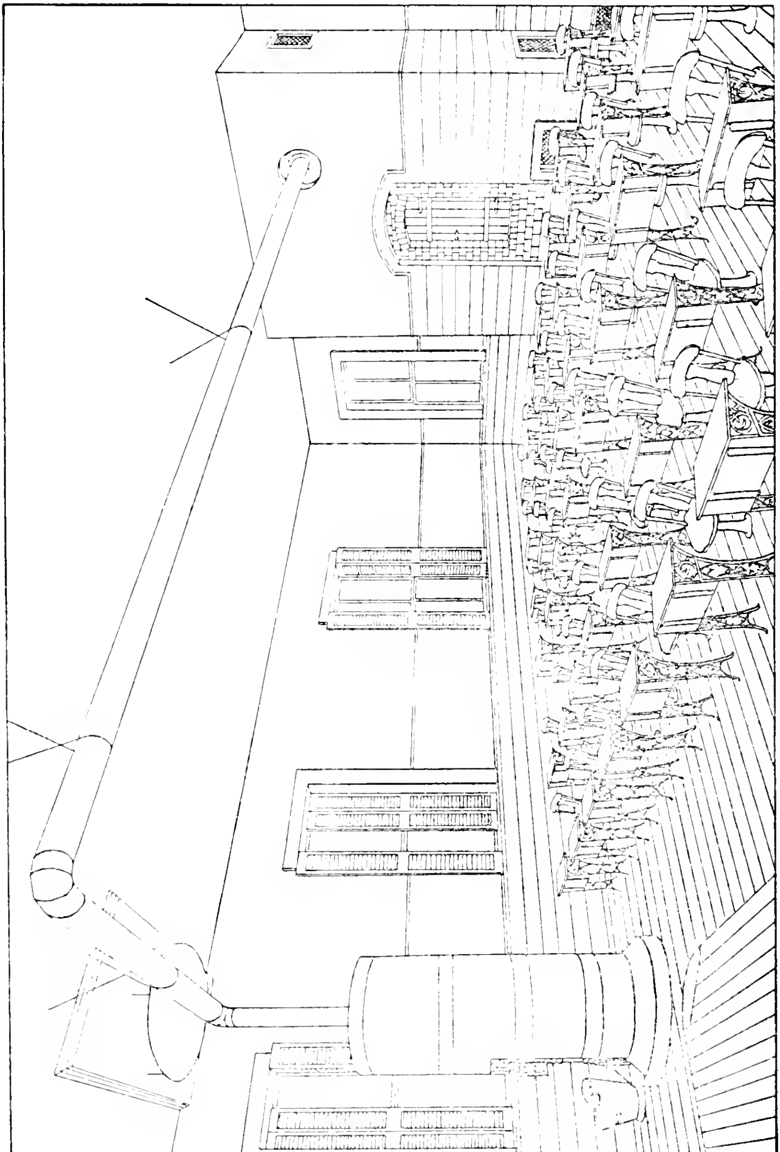
The Blossom Street school house, an eight-room wooden building, was fitted up in almost the same way. Both buildings have passed through one mild winter and half of another with fairly good results, the air supply being found by a few measurements to be up to the standard previously fixed and the air being pronounced good. It has been found troublesome, however, in the mild weather to keep the rooms from getting too hot.

The new building on Baltimore street, built in 1888, has been overhauled in 1889, according to local custom, and its "indirect" steam-heating apparatus greatly increased in capacity. Its imperfect working during the previous winter was partly explained when, in taking off the louvred cupola to make room for an Emerson cap, the foul-air flues were found half covered with boards left in by careless workmen the previous summer. There were, however, no especially new features on this job (except the automatic heat regulator) and no tests have been applied yet, so far as the writer knows.

RED ROCK STREET SCHOOL HOUSE LOWER ROOM

PLAN





As to the cost of the primary school apparatus and its maintenance the writer cannot now do better than to quote from the paper on the ventilation of school rooms heated by stoves, by Dr. J. G. Pinkham, in the Massachusetts State Board of Health Report for 1887.

"*Expense of the System*—This includes the cost of construction and of maintenance. The cost of the improvements at the Red Rock Street schoolhouse, was $567.77; of those at the Baltimore Street schoolhouse, 554.56. At the Chase Avenue schoolhouse $418.16 was originally expended, but subsequent changes considerably increased the cost. Quite a large part of the first cost came from the necessary tearing down and building up again. It is notoriously expensive to make changes in completed buildings. The schoolhouse mechanic, who has had a general oversight of the work of making these improvements, estimates that if put in during the process of construction the apparatus in a two-room building would not cost more than $350; in a one-room building $225. The change could be probably made in an old one-room building for $350. When the arrangements form part of the original plan of a school house, they are likely to be much more satisfactory than when added afterwards.

The cost of maintenance involves an increased outlay for janitor service and for fuel. In country districts where the fires are cared for by voluntary service of teacher and pupils, the former item is not to be reckoned. In Lynn an allowance of fifty cents yer week for each additional stove is made during the season when the fires are in operation. This amounts to something near $40 per year for each building of two rooms.

From our experience thus far it is difficult to form an exact estimate of the increased cost of fuel. The coal and wood are supplied to the city on contract, the bins being filled up when necessary. It is certain the consumption of fuel increases somewhat in proportion to the amount of fresh air supplied. At the Chase Avenue schoolhouse, as near as can be asertained, from five to six tons more of coal have been burned each year since the ventilating apparatus was put in than before. It would be not far from the truth if we should reckon the increased cost of fuel for the building at $30 per year, or $15 for each room. This added to the increased outlay for janitor service makes $35 per room,—surely not an extravagant sum to pay for anything so necessary to health as pure air."

THE PRESIDENT—I am going to ask the Society to pospone discussion on Mr. Perkin's paper until we have heard from Mr. Woodbridge, whom I will now introduce to you, and who will address you upon the subject of ventilation of schoolhouses.

BY PROF. S. H. WOODBRIDGE.

Mr. President and Gentlemen of the Society: What I propose to speak upon to-night is a simple topic,—namely, the application of furnaces to the heating of small schoolhouses. Of course, the thing which is desirable to accomplish in the heating of a schoolhouse, is to secure an effective circulation of a large volume of air at a comparatively low tempera-

ture. The two important requirements in a furnace for heating a schoolhouse are, first, that the furnace shall have a large heating surface, and second, that such surface, heated to only a comparatively low temperature, shall evenly warm large volumes of air moving over it. It is necessary to have a special type of furnace in order to do this work The ordinary furnaces are quite inadequate to such work.

We have as a usual thing, for instance, a cylindrical furnace, standing within a case; this (referring to a drawing) being the furnace itself, standing within an outside case of brick or iron; between the furnace and its case is an annular free space through which the air passes, ultimately finding vent through conductors to different parts of the building. We have, then, here a comparatively small space, according to the distance between the furnace shell and the outside casing: we have a considerable vertical extension of furnace, that is, the air passing in at the bottom becomes more or less heated, by contact with the lower part of the furnace, and in passing upward over that surface it grows hotter and hotter as it ascends to the top, until, when it reaches this point, it has a temperature of from 200 to 250, or even as high as 300 degrees. In this case the general extension of the furnace surface is vertical, the air being heated as, in relatively small quantities, it moves upward continuously against that surface.

Furthermore, the heating surface, as compared with the grate area in a furnace well proportioned for ventilating work, is large. In the ordinary furnaces this is not found to be the case. The heating surface may be itself 20 times the area of the grate, but I think it is exceptional when we get as high as thirty or forty times the area of the grate. What is wanted, then, in order to preform the work of heating and ventilating, is a large heating surface in comparison with the area of the grate.

In the case of steam heating, radiators may have from 150 to 300 times the area of the fire grate, but in the ordinary furnace forty times the area of the grate in heating surface is exceptionally high. What is wanted, then, is a furnace with a large surface and relatively great horizontal extension instead of a small surface with vertical extension. If we could take, for instance, that cylindrical furnace, 3 feet in diameter, and 6 feet high, and turn it over on its side, this way (illustrating), I think you will see in the first place that we should have a large aréa about the furnace through which the air could move, as compared with that of the annular ring in an ordinary furnace of vertical extension. Taking the other section of it for a horizontal extension of the same furnace, we should have a space for air movement of the same width as before, but of a length equal to the horizontal perimeter.

A large horizontal extension, rather than a vertical extension, is required for two reasons: In the first place, in order to get a greater area through which the air may move, and in the second place, in order that the air may not be heated to too high a degree, as is the case with the furnace of vertical extension, to which I have just called your attention. When the air has reached the top of this furnace with longitudinal extension, its temperature may be 150° as against that of 300° in a furnace of vertical extension, such as we have in this (indicating) furnace.

There are other things to be desired in the working and construction of a good furnace. The combustion should be good. The fire pot should not be too deep. The fire should be fairly shallow; there should be an intimacy of contact between the hot combustion gases on the inside and the air on the outside. The shell is the medium that transfers the heat of the combustion gases to the air on the outside; the air on the outside has to be heated, and the gases on the inside have to give up their heat.

What are the furnaces that best fulfil these several conditions? I would say, first of all, the Smead. I do not know that in point of merit I ought to put that first; I do so because we are more familiar with it, and because we have heard more of it to-night, than we have of any other that is constructed for ventilating work. In this furnace we have intimacy of contact between the combustion gases on the inside, and the air on the outside, and a pretty complete transfer of heat is affected. The fires are

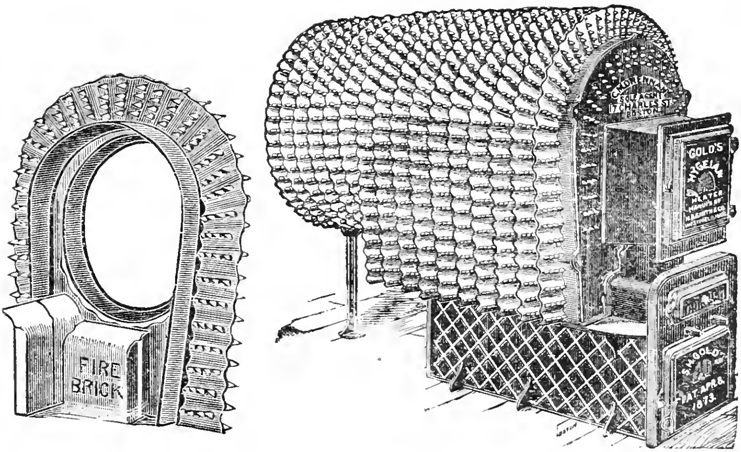


FIG. 1.

shallow,—the provision for complete combustion is good, and the area of the heating surface is large as compared with that of the grate. There are also the Fuller & Warren furnace, and the Mahoney furnace, worthy of mention as furnaces of the better type for ventilation work. But they are all connected with some system of ventilation, and the call comes for some furnace which is independent of any such system. Is there not in the open market some furnace which will answer these purposes, and which is obtainable, independent of any system of ventilation? Must we, in order to procure such a furnace, go to the firms which furnish patent ventilating systems?

I shall now call to your attention a furnace which is as old, in point of invention and manufacture, as any of these which I have mentioned, a furnace which is made in this state, in the town of Westfield, and which is known as the "Gold Hygeian Heater." I have a small model of it here, which I would be pleased to have you examine. The general form of it is similar to that of a locomotive boiler. The body of the furnace is in

box form with arch top, and contains a fairly shallow fire-box and large combustion chamber. The cylindrical part of this furnace may be extended almost indefinitely by means of rings attached to the body of the furnace, and to each other by bolts. We have in this furnace a horizontal, rather than a vertical extension of surface. Beyond this, we have upon the body of the furnace itself and upon the extension rings, rigidly attached to them as one piece with them, cast iron flanges, and attached to these flanges are spurs, or pins, which greatly extend the surface of the heater. The heating surface is, therefore, so large in proportion to that of the grate that it cannot have a very high temperature. I should say, also, that the fire pot is lined with brick, so that that part of the furnace cannot be highly heated, or it cannot be heated to anything like a red heat.

The external surface is about eight times the internal, and the area of the exterior surface, in such a form as this before you, is about 100 times the area of the grate. This ratio may be made much larger by extending the cylindrical part of the furnace. The rings making up this part are very carefully put together, sleeving closely one into the other; and they are drawn and held together tightly by short bolts, so that it is practically a very tight furnace, and it is not especially liable to breakage by warping. There is one objection which may occur to you, and that is in the unequal heating of the shell and the flanges, tending to breakage; but that danger has been avoided by making the flanges of corrugated form rather than of more rigid plane form as you see them here.

For completeness of combustion; which is always desirable, the furnace

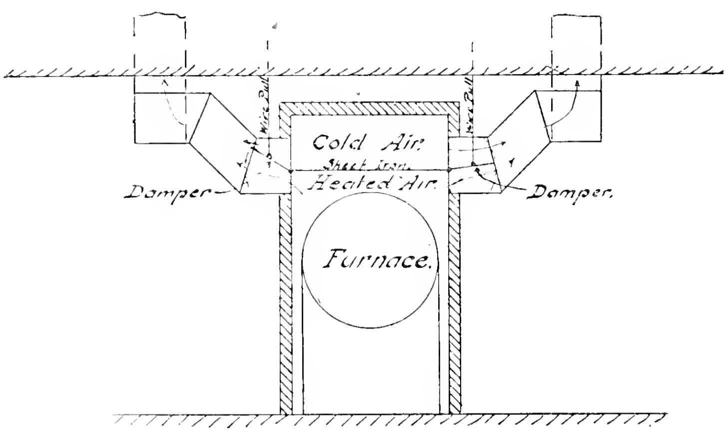


Fig. 2.

has a large combustion chamber, and the gases in rising from the coal, from one part carbonic oxide gas and from another part air, have a chance to mingle and to complete the combustion before coming into contact with the cool surfaces of the furnace. There is, furthermore, a very finely perforated plate in front admitting air, which, on striking upon and pass-

ing over the fire, becomes heated, so that it is quite common to see, in the rear and upper part of the furnace, the blue flame characteristic of the burning of carbonic oxide gas.

As to the matter of applying this furnace to use, I have sketched upon these papers before you a general plan for the adaptation of such a furnace as this to the heating of small school houses. I would say that I would not rely upon such a furnace as this to heat a larger space nor a greater air volume than would be required by 100 scholars. I think that it would provide liberally for what would be required by that number. Let me go through an explanation of these figures in order that you may understand the plan which I would propose for its use. The general plan of the furnace and the proposed methods of encasing it are represented by Figs. 2 and 3. In regard to the furnace itself you may note in these figures a

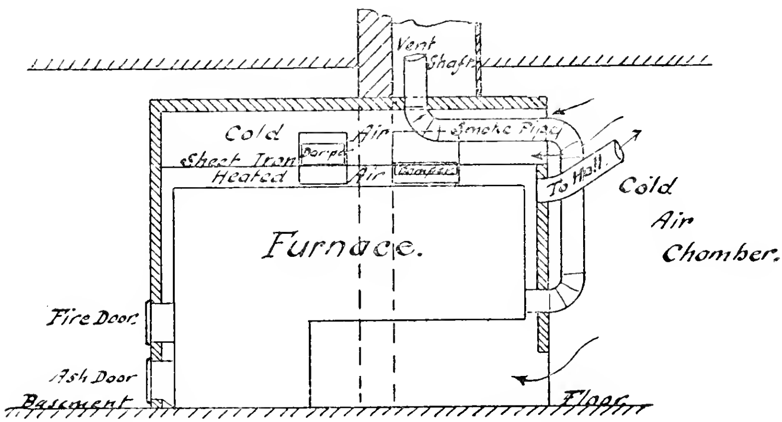


Fig. 3.

point which may have escaped attention in looking at the model, and that is that the smoke vent is so placed as to take the cooler gases from the combustion chamber. The furnace is placed in a case, such as you may perhaps see to better advantage in Fig. 3. The cold air passes into the heating chamber through a large aperture 4 feet by 18 inches, at the lower part of the rear wall of the casing, passing up by the pin-covered flanges and becoming mildly heated as it reaches the upper part of the chamber.

If several rooms are to be heated from one hot-air source, provision must be made for giving different or required temperature to the air distributed from that source. Sometimes it is required to heat one room to a certain temperature and another room to a different temperature. If only one room is to be heated, the fire may be regulated so as to produce the temperature required; if several rooms are to be heated, the fire must be regulated so as to produce the temperature required in the room most difficult to heat. The furnace temperature must be governed by the requirement of the room demanding the highest temperature of air

supply, and some ready and effective means must be employed for reducing that temperature, but not the volume of air supply to other rooms.

I have represented here a method of doing that which I have, in several instances, recommended, and which I am glad to have an opportunity to call to your attention this evening. In the lower part of the furnace is, as usual, the cold-air box terminal, but in this plan we have another cold-air chamber on the top of the furnace as well. Such an arrangement has this advantage. The top or any part of a furnace in close proximity to woodwork should be kept cool (and our Inspectors are properly careful to take all reasonable precaution to provide against the possibility of fire from such cause.) This method affords an effective means of keeping the upper part of the furnace perfectly cool, so that when the furnace has been heated to its hottest, the top will feel cool to the touch, for the colder the weather and the hotter the fire the cooler will this top be. But, further than that, we see that it provides for cold air to be mixed with the heated air for distribution to the different rooms. The heated air and the cold air are separated by a diaphragm, and their passage into the supply conduits allowed or checked by the movement of a valve, which controls the quantities of each which may pass and mix beyond it. In the left hand conduit the valve is shown in a position to allow the heated air to pass freely and to hold the cold in check. The right-hand valve shows a more equal movement, resulting in lower temperature of supply.

Then, as to the size of the flues. Manifestly, flues such size should be provided that the full quantity of air shall be supplied with the smallest difference of temperature between the air inside of the supply flue and the outside air, under which the system is to furnish required ventilation. The flues must be of such capacity as to supply and remove the required air volume when the outside temperature is just too cool to open windows. If we attempt to use such flues in cold weather without throttling them the quantity of air moved through the furnace will be altogether too great to be heated and greatly in excess of requirement. The most air is needed in the warmest weather and the least air in the coldest weather. There should, then, be provided some means by which the ventilating flues can be reduced according to the increased difference between the inside and outside temperatures.

In Fig. 2 is shown the means for such regulation of flue area in the supply system. The sum of the hot and the cold air apertures from the furnace to the conduits to which they belong is equal to the area of the conduits. The hot air apertures are in area one-third, and the cold air are two-thirds that of the connected conduits. If the weather is cold not much cold air is needed, and by simply drawing up a damper by means of a wire and chain, the effective area is reduced to one-third of the total area available and required in mild weather, and shown in the right-hand conduit. As far, then, as the supply part of the system is concerned, I think you will see that this matter has been considered and has been provided for, as I think we seldom find it provided for in the methods of ventilation which we have had occasion to study, for, as a rule, no attempt is made to alter the size of the flue inversely as the velocity of the air-flow through it.

The general arrangement for the location of a furnace is shown in Fig. 4. The furnace is placed in the basement, of course, and the flues, which are also shown in Figs. 5 and 6, are placed as near as possible to it, one of them going up to the first story and the other to the second story, the one

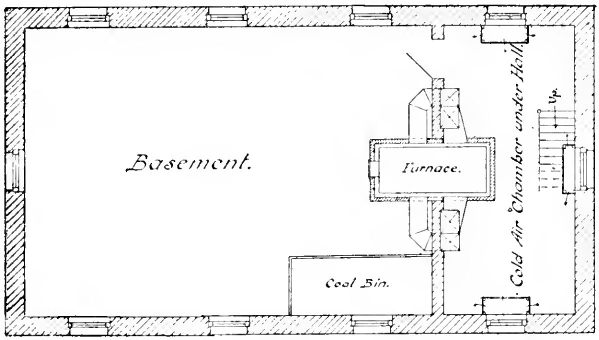


Fig. 4.

going to the second story being the smaller flue, because its greater height gives it a stronger draught power than the shorter one. These areas are about as two to three.

One of the special features of this arrangement is this, that the whole space at the front end of the school building is a cold-air box having three windows on as many sides opening into it, so that the furnace is vir-

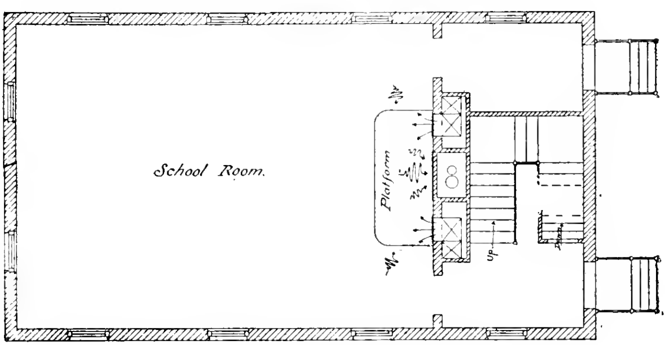


Fig. 5.

tually standing out of doors. It does away with the chief objections to the cold-air box, with its necessarily contracted area and its frictional resistance to flow and the retarding effect of bends, etc., for the access of air through the windows and large chamber is relatively free. These windows are arranged to provide against failure to secure air supply in the case of strong winds, about which I shall have occasion to speak a little later.

Thus far I have spoken of the furnace, the general management of the flues, their size, the longer being about 20 by 18 inches, and the shorter about 20 by 24 inches, the means for regulating areas and for admitting air supply to the furnace. We now come to a notice of the exhaust and discharge part of the system.

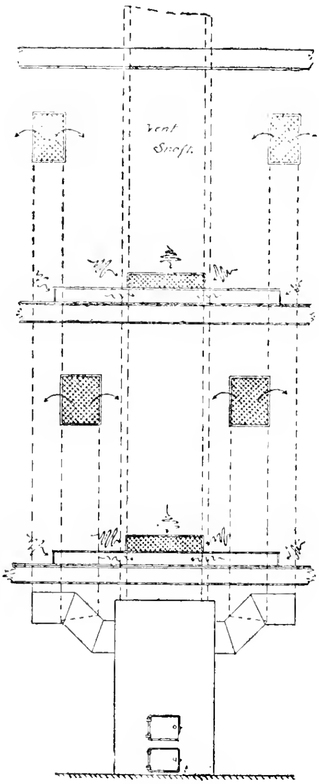


Fig. 6.

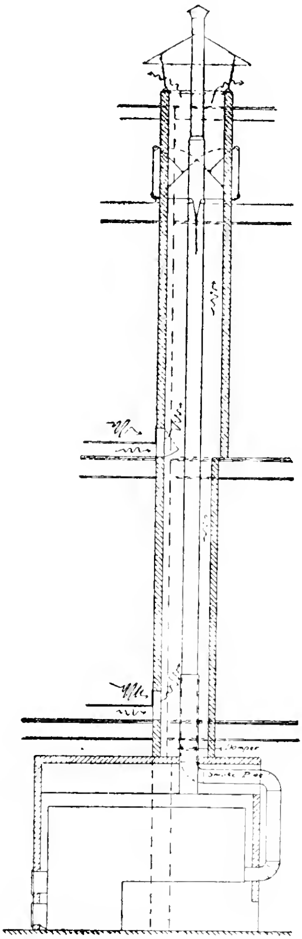


Fig. 7.

The exhaust aperture is at the floor, partly underneath and partly above the platform, on the same side with the air inlets. In Figs. 5 and 6 note the relative position of the supply and vent apertures. Manifestly in such a room as this, with three cold sides, the warm air rising to and floating at the ceiling will be chilled by contact with the walls and windows and thrown down; it will then tend to move across the floor and away from the

walls and in directions whose resultant point would be somewhere in front of the platform, and the vent opening might perhaps better be at that point, but convenience in construction and cleanliness also favor the location shown and efficiency is practically unimpaired. The areas both of vent and of discharge are in all cases large.

I would call your attention to another point in connection with the discharge. The furnace pipe is made to pass around and up through the discharge shaft, as you see in Fig. 7. An 8-inch pipe is fitted to the furnace collar and that pipe is enlarged to a 10-inch within the flue in order to get a larger surface for heating the air in the flue, and also to secure a slower movement and longer retention of the hot gases through it. But there are times when a greater heat will be wanted than can be furnished by this pipe. When, in warm weather, the temperature of the furnace is lowest, we want the highest temperature in the vent flue, and by the arrangement thus far considered we get the reverse of what is actually needed.

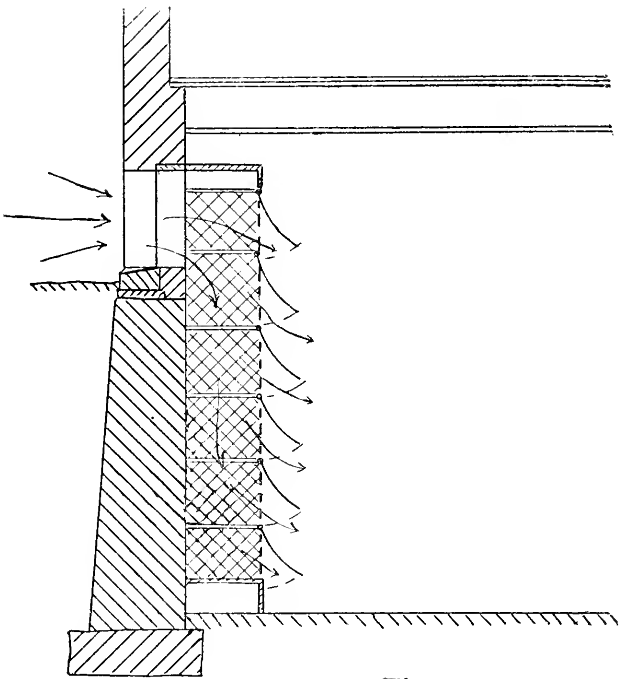


Fig. 8.

But if at such times the furnace heat not wanted in the rooms could be diverted into the ventilating flue the desired condition would be realized. The figure shows a 15-inch pipe connecting the ventilating shaft with the hot-air chamber of the furnace, and through which, by the opening of a damper, the heated air may be passed. So that when there is an excess of heat in the furnace for the requirements of warmth, it is possible to open

up this damper to admit the heated air to the vent flue, the air passing from the furnace directly into that flue, and so giving the extra warmth required. To be sure, we are then passing fresh air into the flue and in so far displacing foul air, but I consider that a better method than putting a stove into the vent flue of a little school house and trusting to the janitor, who visits the school but once or twice a day, to look after and keep up

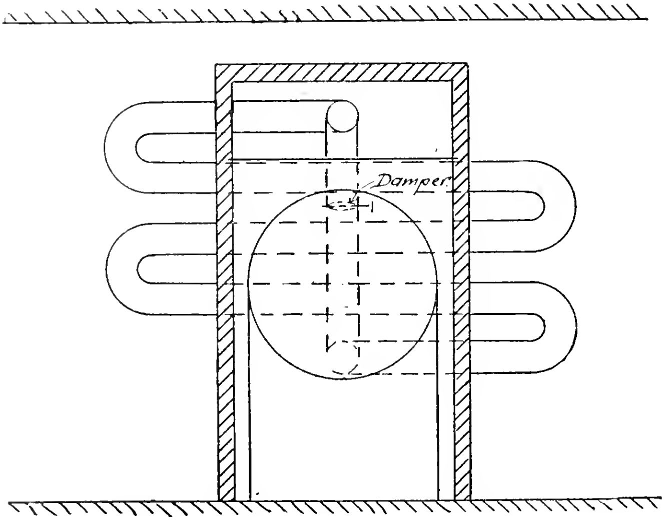


Fig. 9.

the fire, or even trusting to the teachers, who have something else to do than to poke fires and feed them with coal.

This vent flue as well as those for supply must, of course, be controlled in its area. It is done by means of two dampers hinged as shown, and opened to requirement by cords passing over pulleys and brought as one down into the principal's room, with means for securing it at notches, which might be conveniently marked for 0°, 10°, 20°, etc., weather, as indicated by an outside thermometer.

There is another point to which I would call your attention in regard to the adaptation of the furnace to the work of ventilation. I have shown, in Fig. 8, a method of arranging the inlet windows, so as to prevent loss of air. Ordinarily, if the air is blowing in through a chamber window strongly on one side, it will be, in part, passing out on the other, or leeward side, and to that extent will be lost. Therefore it is desirable to arrange the inlets so that in whichever way the wind blows, the desired quantity shall be passing into the room. Suppose a long, vertical box, covered with wire cloth, through which the air can easily pass, be placed before each window, and that over that wire netting light gossamer strips

or valves are hung. With the least air pressure these are thrown out, letting the air in freely. Whenever the wind blows in through the window the valve is open and the air passes through, but the moment the wind takes the opposite direction these valves close. Therefore, if the air blows in strongly on one side it merely closes up all the valves on the other sides and keeps in the chamber all the air that would otherwise escape, and the influence is at once felt in the pressure produced on the furnace. In still weather the air will come in through all these windows gradually, slightly lifting the valves, and whenever the high wind would tend to disturb the action of the furnace, such action is prevented by the closing of the leeward valves.

One thing more in connection with this furnace. I have said that when the air is warm outside but little heat is wanted in the furnace, and that it would better pass up the ventilating flue. In other words, very little heat is wanted from the furnace in warm weather, and in cold weather the total produced is wanted. It must be said that this furnace is not altogether what could be desired for the transfer of heat from the gases to the air. That is one of its failings, in fact, I may say that it is the failing of this furnace. Although we have large area and intimacy of contact on the outside, we have not a correspondingly large area and provision for intimacy of contact on the inside. The combustion gases may pass off from this furnace pretty hot. I have seen a pipe that was red hot for some little distance (20 feet) from the fire pot. Of course it was an unsafe fire and a needlessly hot one, the combustion chamber being filled with wood and a strong draught drawing the flames well into the chimney. The janitor in charge was making a frantic effort to make up for his ignorance of the use of dampers by forcing of fires.

What is wanted here is, of course, some means of transferring to the supply air that otherwise waste heat.

Fig. 9 shows an arrangement proposed for this purpose. The direct and vertical pipe which goes into the vent flue has a damper which may be closed. The closing of this damper forces the hot gases to pass through the long trombone-formed pipe, shortened in the figure for want of space. The combustion gases make a tortuous course; the current is broken at each turn, and the conditions are favorable for a large transfer of the contained heat.

This, Mr. President and Gentlemen of the Society, I would say, in general, in answer to the query which has come from many quarters as to the possible means of heating and ventilating by a furnace, and the method of its adaptation to what I should call rather small work. [Applause.]

DISCUSSION.

THE PRESIDENT.—Gentlemen, I am sure that you have all listened with interest to these papers, and, as the night is still young, we have plenty of time for discussion.

MR. McCLINTOCK.—I would like to ask Prof. Woodbridge whether

in his opinion the rings on the outside of the furnace described have any actual influence, or whether it would not be just as well in a plain cylindrical form, as with the rings?

PROF. WOODBRIDGE.—I think not, for the simple reason that the flanges are cast in one piece with the parts to which they belong, and are a part of the furnace itself: and these flanges becoming chilled tend to keep the shell to which they are attached much cooler than it would be without them, and the cooler the shell the more perfect the transfer of the heat of the gases inside of that shell; and, further, the effect gotten from so extended a surface moderately warmed is very much to be preferred to the same heat yielded to air by a small surface highly heated. There has been, in no case that I have had occasion to observe, any overheating of the air.

The question, as I apprehend it, is simply this: Given a certain amount of furnace shell surface exposed on its inside to combustion gases at fixed temperature, and on its outside to cooler air, by which of two ways will that shell transfer the heat most rapidly; by the contact of cool air with a plane outside surface, or by conduction through continuous metal kept cool by the movement of air over an extended surface?

When the extended surface is, in form and exposure, such as to allow as free a movement of air over it as would be had over the corresponding plane surface, the heat transfer is increased, and for these reasons: First, the transfer of heat by convection per unit of surface, varies directly as the temperature difference between that surface and the impinging air. Second, the rate of transfer of heat between two planes represented by one inch of continuous iron is 390 times that yielded by convection when the two planes have the same temperature difference as that existing between the air and the warmer surface. Hence, if the surface next the combustion gases is maintained at a fixed temperature, the temperature difference between an extended surface and the impinging air cannot vary inversely as the ratio of extension, but must be in considerable excess of the ratio, because of the rapid transfer of heat by conduction. Thus, if the temperature difference between the plane surface and the air were 300°, by the extension of that surface to twelve areas, the temperature difference between it and the air would not drop to 25°, but would be maintained at, say, 50° to 75°.

If the objection is made that the rapid cooling of the furnace shell makes its fire-exposed temperature so low that the assumption on which the argument just made is based becomes untenable, that very objection contains all the argument desired in favor of extended surface, since the cooler the furnace shell the more rapid and complete must be the transfer of heat from the combustion gases to it, and from the shell to the air.

MR. KNAPP.—I would like to inquire what explanation Prof. Woodbridge can give of what happens to the overheated air that comes in contact with the red hot iron, and which makes it objectionable?

PROF. WOODBRIDGE.—My answer to that would be this: The amount of dust floating in the air, the purest air obtainable or found within our buildings, is much larger than is generally supposed. Not until a room is darkened and a sunbeam is "seen" by the reflection of its light

from the dust in its path, do we begin to have any idea of the quantity of dust there may be and is in air which has seemed pure. Concentrate that sunbeam by a lens, and the dust seems to become so thick that the vision cannot penetrate it; and one would be loth to take the next breath from that spot to which it would seem that all the dust in the room had betaken itself.

If such air comes in contact with hot surfaces, the organic matter in it is cooked and burnt; it is changed into a charred material, into fumes, into gases, and into smoke; and I presume that when ordinary dust-laden air touches surfaces which are overheated, the disagreeable results peculiar to overheating are largely due to the effect of heat on the floating matter which is in the air.

MR. McCLINTOCK—I would like to ask one other question of Prof. Woodbridge relative to his statement that we need more air in warm weather than we do in cold weather. I would like to inquire what is meant by that statement exactly, as I am not sure that I caught his meaning fully.

PROF. WOODBRIDGE.—Well, sir, it is this, as I hold it. Organic matter is always present in the air. Two things are in general required to make that organic matter offensive, if not morbific. One is heat, and the other is moisture. The air is drier as it comes into our houses in the winter than it is in milder weather; in milder weather it is moist and it is also warm; and because of those two conditions, favorable to the decomposition of organic matter in the air, much more air is required for comfort in warm weather than in cold weather, when it comes into our houses in a much drier condition. The drier the air and the colder the air, the less will be the quantity required for agreeableness and for health. The carbonic acid gas becomes then the principal thing which we have to consider as a test of impurity. But when the weather is mild and moist, other things force themselves on our consideration. An air quantity which would be perfectly satisfactory on a winter's day would not be tolerated in the summer season, when the air is moist as well as warm. It would not only be intolerable, it would be morbific. In the summer we must have open windows and a natural ventilation, compared with which in effective work artificial ventilation is child's play. "We must have more moisture," it is said; "we must endeavor to imitate nature, and produce within doors all winter long the balmy air of delightful June. Not until Art reproduces Nature is her work perfectly done." But let us not follow her half way; give us, if you please Nature's moisture; but with it give us Nature's volume, not moistuie alone. We must have greater volumes as we increase the moisture of our air.

PROF. WATSON.—This recalls to my mind a circumstance which occured this summer in regard to the proper method of ventilation. Quite a distinguished hygienist made a statement that we ought never to have warm air, that the rooms should be heated by coils or whatever else, but that the cold air must be introduced, because the warm air had the life taken out of it. I suppose that that would refer to a milder climate than ours. He was in favor of admitting cool air, but putting around the rooms sufficient apparatus for warming thoroughly, imitating the action of placing ourselves before the fire.

MR. TUDOR.—The furnace imitates that in a very compact space.

PROF. WATSON.—No. He wanted the body warm, but the air in the room cold.

MR. TUDOR.—There is no doubt that in a room that has been warmed beforehand by fire, you can bear a very much cooler atmosphere, but there is great difficulty in doing it.

MR. ADAMS.—I would like to ask Prof. Woodbridge if another reason why the inlet flues should be wider open in summer is not that the velocity of the air is smaller on account of the smaller difference in temperature between the inside and outside air.

PROF. WOODBRIDGE.—Yes. I meant to have brought that out in what I said, that the areas of the flues should be adapted to that difference of temperature.

MR. MCCLINTOCK.—The question that Mr. Adams has just asked Prof. Woodbridge was perhaps the one that I wished to ask before—whether what he means is really that we need more air in warm weather than we do in cold weather, or whether he means by that statement that we have a higher velocity in cold weather than in warm weather, and that consequently we get more air into our houses through a given space in a given time. I did not get his meaning exactly on that point, I think.

PROF. WOODBRIDGE.—I certainly hold that we need more air in warm weather than in cold weather; of course, if our flues remained the same size in all weathers, we should get the reverse action.

Allow me to call the attention of the Society to one point that I failed to speak of, namely, that a building arranged as has been shown may be easily heated by means of the rotation of the air through the furnace, since by open doors into the hallways and into the cold air chamber the cold air may be made to settle from the upper rooms to the lower, and thence into the cellar, to be rotated through the furnace. I have no doubt that there is some decided economical advantage in heating a building by rotation rather than by heating air taken from the outside.

MR. PERKINS.—I would like to ask Prof. Woodbridge a question in regard to his cold air chamber as shown on the drawing. The question is whether such a chamber would not be sufficient of itself, without any special arrangement of the windows. In a room like that, which is open on three sides to the weather, with the wind allowed to blow through freely from side to side, would not the furnace take sufficient air for its operation, and no more?

PROF. WOODBRIDGE.—I should be afraid of that under some conditions. For instance, suppose that the air was blowing in this (indicated) direction, blowing in strongly through this window. [Mr. Woodbridge proceeds to explain, illustrating by means of the windows in the room occupied by the Society how a vacuum might be created on the leeward side of a building, tending to draw the air out from the chamber through two windows, while blowing strongly in through one windward window.]

It is desirable to avoid, if possible, that vacuum effect, and to get through the one aperture a quantity of air which would equal the volume passing through all three spaces in the normal state. I should recommend the check valve arrangement, which has worked well in a number of cases.

THE PRESIDENT.—Do you know of any school houses in this neighborhood which are fitted up in that way?

PROF. WOODBRIDGE.—Not in that complete way. There are three school houses in Milton in which this furnace is used, but they are connected with the open air by cold-air boxes having an area in cross sections of 6 square feet to each furnace and taking air in on both sides. In these check valves were put, with the result of overcoming the difficulty which had previously been experienced of a direct current through the cold-air boxes, the air going in on one side and escaping in part on the other side.

THE PRESIDENT.—Was the system of flues the same?

PROF. WOODBRIDGE.—No, sir. The system of flues was not the same, because the object was not to make a model arrangement, but to so change the existing condition of things as to obtain tolerably good ventilation. The flues are in each case in the back part of the building. They are small and not very well adapted to this work. The question there was how to most economically secure fairly good results, and I think that so far as the supply of air is concerned, satisfaction has been given. The vent is the weakest part in these systems as they stand.

THE PRESIDENT.—How do you arrange for an examination of this pipe inside of that flue? (Figs. 6 and 7.)

PROF. WOODBRIDGE.—The flue is a large one. It is 4 feet by 30 inches, I think, in its smallest part, something like that.

There may be doorways opening into that flue. It may be made of brick or of wood and tin lined, either construction admitting of doors.

THE PRESIDENT.—There is a free access then.

PROF WOODBRIDGE.—A free access.

MR. E. W. HOWE.—Prof. Woodbridge made a statement at the beginning of his remarks to the effect that in school houses we wanted a large heating surface to heat the air to a moderate temperature, while in private houses we wanted a small heating surface to heat the air to a high temperature. Why do the conditions differ in the two? Why should a higher temperature be required in a private house?

PROF. WOODBRIDGE.—In the private house there are comparatively few persons and a very large wall surface and natural ventilation, a large factor in such a building, is going on continuously. By "natural ventilation" I mean ventilation through other than provided means. The number of per capita square feet of window and wall area is very large, so that there is a very large inward leakage of cold air at the bottom and of warm air at the top of the building or rooms. We want to *warm* that house to heat the air provided by natural ventilation. Naturally we want, then, a higher temperature of air and in a smaller quantity than in a house depending on artificial ventilation solely; in the first place, because the number of persons there is small, and in the second place, because there is such a large inward leakage of air which must be warmed by some means. But, in the case of school buildings, the per capita natural ventilation is small, large air volumes must be supplied by provided means, and for the very reason that it is large, it requires to be heated to a comparatively low temperature.

Mr. Adams.—I should like to ask Prof. Woodbridge one other question, and that is whether he has ever advised any special means for adding to the humidity of the air.

Prof. Woodbridge.—I have not done so as a rule except where it has seemed to be required. You can easily figure out the amount of evaporation necessary to effect any considerable change in the humidity of air. It seems to me mere child's play to add the little amount by evaporation which we get by the ordinary methods employed for that purpose. Figure it out and you will find that it is very small. Let us do it roughly. We are passing into a school building with fifty pupils in it, 100,000 cubic feet of air an hour; we are taking it in from the outside at a temperature of 30, when it has, say, 1.5 grains of water to a cubic foot of air, we will raise the temperature to 70, say. It would hold about 8 grains of water at that temperature; therefore there would be just about 6.5 grains to be added to saturate or 4 grains to raise the relative humidity to 60. Multiply that by 100,000 and we have 400,000 grains of water to be added to the air in that school room; that is to say, 400,000 divided by 7,000 equal 57 pounds of water per hour required to effect June humidity. Usually four or five pounds of water per hour is, I think, a generous rate of water evaporation in school house furnaces or about one-third grain per cubic foot of air.

See what sort of an arrangement would be required to evaporate that water. As much coal would be required for water evaporation as for heating the air. And then what have we got? A warm and moist air, and the organic matter in dust, vapor and other form becomes evident by its quicker decomposition, its offensiveness and its unwholesomeness; and, further, we have a humidity within doors which we do not get when we are outside, making the effect of a quick transition the more hazardous. I think that the conditions are excellent when we get pretty dry air, 20 per cent. or even 15 per cent. of moisture. The English require a higher humidity because all their living is in a moister climate. Disease germs and zymotic diseases do not thrive in a perfectly dry state. I think that the case cited by Dr. Billings is an excellent illustration of what I have in mind. At a United States military post in New Mexico, I believe, the temperature is often 120° in the shade and the air is phenomenally dry. By way of effective statement in illustration of this fact it is currently reported in regard to a vicious soldier who died and was buried that his comrades were awakened during the night following by a rapping at the window, and upon asking who was there and what was wanted, they learned that the old fellow had come back for his blanket. [Laughter.] That camp was a tolerably hot and *dry* place, and diseases of a malarial type were unknown.

Mr. H. D. Woods.—I would like to ask Prof. Woodbridge if there is any advantage in having a cold-air box below the brick work rather than above it? Does that not cool off the heated brick work?

Prof. Woodbridge.—Certainly somewhat, but the process of cooling is very slow. The air below the iron diaphragm is cooled a little, but the air above it is heated proportionately and no heat is lost.

MR. WOODS.—But that may be done at a time when you are not needing that air.

PROF. WOODBRIDGE.—That air is almost always needed. If not in one room, then in another.

MR. WOODS.—I want to ask whether the furnace could not be improved by so changing those rings as to make the combustion gases take alternate directions up and down or to and fro in their movement through the cylindrical part toward the vent by using diaphragms?

PROF. WOODBRIDGE.—I think very likely. It is not a model furnace so far as intimacy of contact of combustion gases with the shell is concerned, but yet is admirably adapted for this kind of work, as has been demonstrated.

THE PRESIDENT.—Gentlemen, I invited two or three other experts on the subject of ventilation to come here to-night. I have received letters from them stating that they were unable to be here. If there is no objections we will consider that the Secretary has read these letters.

ERRATUM.—On the seventh line from bottom of page 158, *phenol-phalin* should read, phenolphthalien.

ASSOCIATION OF ENGINEERING SOCIETIES.

PROCEEDINGS.

CIVIL ENGINEERS' CLUB OF CLEVELAND.

FEBRUARY 11, 1890.—The meeting was opened at 8 P. M. Mr. W. R. Warner, President, in the chair. The Secretary read the minutes of the previous meeting, which were approved. He also read a communication from the Executive Board, including letters of application from the following persons, for membership in the Club: Ralph Augustus Harmon, Assistant Manager of the Cleveland City Forge & Iron Co., and Hiram Kimball, Manager Turn Buckle department of the Cleveland City Forge & Iron Co.

The following persons were unanimously elected by twenty-one votes for active membership in the Club: Arendt Angstrom, ship designer of the Cleveland Ship Building Co., and James C. Wallace, Engine Designer of the Cleveland Ship Building Co.

Mr. John Whitelaw then read a report of the Committees giving two lists of proposed officers for the ensuing year.

The President alluded to the annual banquets, which the Club had previously had, and asked what the members thought of having one as usual this year.

Mr. Leland moved that the banquet be omitted this year, as many of the members had not manifested the proper interest in it heretofore, and the Committee suffered a great deal of anxiety, in working to make the banquet a success, yet only about seventy-five tickets were sold, and all of them did not put in appearance.

Mr. Mordecai said he was not of the same opinion as Mr. Leland in regard to dispensing with the banquet, but in order that it be brought properly before the house he would second Mr. Leland's motion.

Mr. Searles said: "In my opinion, Mr. President, the banquet ought not to be omitted on general principles. I think it is conducive to the prosperity of the Club to have such an anniversary, and while there is a great deal of labor connected with the arrangement of it, still I think we have always paid for everything that has been required for it, and have always voted afterwards that we had a good time. I think we should certainly do something at least once a year, and there is no more proper time than at the annual meeting. The motion as it stands should certainly be voted against, and I think there are others here that can speak on this subject as well as myself."

The President then said, that as Mr. Holloway, who had for some time past been away was present, he would like to hear from him regarding the subject.

Mr. Holloway in response said: "I think the Club should have a banquet, and a glorious one, and that each member should take hold to make it a success, and I advise that the banquet be not dispensed with.

Mr. Leland's motion was lost.

It was then voted that a banquet be held, and the President proposed that the Chairman of Programme Committees, act as banquet committee.

Mr. Mordecai moved that a committee of seven be appointed to take charge of the banquet, which was carried.

Mr. Edward Lindsley read a paper on "The Improvement of Railway Terminal Facilities as related to the Transfer of Coarse Bulk Freight," showing a model of a machine for that purpose.

Ex-Secretary, Mr. James Ritchie, read a short paper entitled "Requirements for

Specifications for Steel and Iron, briefly noting errors made in the usual specifications, which was followed by discussion.

Mr. Kingsley then read a paper entitled "Notes on the Water Works Lake Tunnel," illustrating the same by photographs. He said that the tunnel will be completed in seven months, possibly in less time.

The President appointed as a committee for the arrangement of a banquet, the following gentlemen: Messrs. W. H. Searles, A. Mordecai, J. L. Gobeille, C. G. Force, Jr., H. C. Thompson, N. B. Wood, S. J. Baker, H. M. Claflen, and C. P. Leland.

The President also announced that the several committees would report on the progress for the past year at the next meeting, and that a ten minute paper from each would be expected.

Mr. Holloway was called upon to say something about the Engineering Club of New York, and made the following remarks:

"The American Society of Mechanical Engineers have taken a house at No. 64 Madison Ave., and have fitted it up. They have a library and reading room. It makes a popular resort for the evening for gentlemen to call in and look over Engineering Journals, as well as to talk of the news of the day. The engineers of New York have their several societies in which technical papers are read, followed by discussion, but a want was felt among the engineers of that city, as well as those outside, that something ought to be done to give them a closer acquaintance with one another.

Engineers are widely separated, and there seemed to be a great want of means for getting together. That this is true, is shown by the great success of Engineering Societies of New York, and some discussion was had as to what the new society should be called. There were those who felt as Alexander Holly had done a great deal in the way of engineering, they ought to name the Club after him. But this was not deemed broad enough, and finally the name of "Engineers' Club," was adopted.

"They rented a large New York house, No. 10 W. 29th St., fitted it up with a fine restaurant, library and reading room. They have a place where engineers can get together and have their feet under the same table, and talk with each other. It was formed in the summer, when a great many people were away. When Fall came, we thought of a change to add to its pleasure, and that was, having informal dinners; so that any member coming from his business, wherever it was, could come informally and have what we called Fortnightly dinners. We had to guarantee the Chef that a certain number would be there in order to get a good one for $1.00

"We begun with twenty-four at dinner and have increased until we have fifty. They are not all residents of New York. They come from Colorado, Australia, and all parts of the world. They come there and find it a good place to meet.

I remember two or three dinners when they were telling stories about their travels, everybody telling adventures; there was one gentleman there from Australia, one from Peru, one from England, one or two from Colorado, and of course quite a number from the different states.

The dinners are so informal that no one hesitates when called upon to say something. We had a couple of Russian gentlemem there who were here in this country inspecting railways. It is an excellent way of becoming acquainted with matters of to-day.

"The Club is very prosperous, having over 400 members and it is constantly increasing its membership. It has a place in which to invite prominent men and Societies who happen to be in New York.

"The American engineers who went abroad last summer were tendered a reception at the Club Rooms on their return.

The other day we had a meeting of engineers there for the purpose of preparing and formulating plans to receive The Iron & Steel Institute of Great Britain. Among those present were Messrs. Carnegie, Ex-Mayor Cooper and Ex-Mayor Hewitt."

Meeting adjourned. C. O. PALMER, Secretary

ANNUAL MEETING.—The annual meeting of the Civil Engineers' Club of Cleveland, was held March 11, 1890, at 8 p. m., President W. R. Warner in the chair.

The Secretary read the minutes of the last meeting, which after correction, were approved.

Messrs. Ralph A. Harmon and Hiram Kimball, both of the Cleveland City Forge & Iron Co., were elected active members.

The application of Mr. Harvey Fitch Coleman, of King Iron Bridge Manufacturing Co., for active membership was then favorably reported.

Mr. Searles, Chairman of Banquet Committee made a report on the arrangements for the approaching banquet.

The President appointed Messrs. H. B. Strong and John Whitelaw as tellers to count the ballots for officers for the ensuing year. Reports were presented on the progress in engineering for the year by the Chairmen of the different committees, as follows: On Civil Engineering and Surveying, C. G. Force, Jr.; on Railroad Engineering, August Mordecai; on Architecture, J. N. Richardson; also on Mechanical Engineering, read for the Chairman of that committee, by Mr. Walter Miller.

The President presented the annual report of the Executive Board, accompanied by the annual reports of the Treasurer, S. J. Baker, and of the Secretary, Mr. C. O. Palmer.

ANNUAL REPORT OF THE SECRETARY.

The following report is respectfully submitted for the year ending March 11, 1890:

There have been held eleven regular and two semi-monthly meetings of the Club during the year. Also the annual banquet at the Kennard House, March 14, and a picnic at Cottage Grove Lake, August 13, 1889. The attendance at the banquet was about 75, and at the picnic about 75 in all. Aside from these two social gatherings the total attendance at the 13 meetings was 304 members, or an average of 23 to 24 members at each meeting. Also an average of 6 visitors to each meeting, at which the visitors were recorded, which were only the last five.

The membership of the Club at present is as follows: Active, 121; honorary, 4; corresponding, 5; associate, 5. Total, 135 members.

There have been elected during the year 1 associate and 17 active members. There have been no resignations from the Club and no deaths.

The resignation of Mr. James Ritchie as secretary, (made necessary by his change of residence to Pittsburgh), was accepted August 13, 1889, and the undersigned elected to the office.

There have been 21 technical papers read before the Club during the past year, (counting two lectures as papers), as follows:

April 9, 1889. Prof. Cady Staley. Flush Tanks for Sewers.

May 14th. Mr. James Ritchie. Erection of Iron Bridges, Cleveland & Mahoning Valley Railroad.

June 11th. Prof. Edward W. Morley. Wave Length of Sodium Light.

June 11th. Mr. N. B. Wood. How shall We Warm, Ventilate and Closet Our School Buildings.

July 9th. Mr. Frank S. Barnum. Modern House Architecture.

Sept. 10th. Mr. W. H. Searles. Engineering Notes in England.

Oct. 8th. Mr. J. H. Dow (not a member). Notes on New Compound Steam Turbine.

Oct. 8th. Mr. N. S. Possons. Electric Motors as Applied to the Propulsion of Street Cars.

Nov. 12th. Mr. George Bartol. Recent Developments in Steel and Iron Manufacture.

Nov. 26th. Mr. N. B. Wood. Facts and Speculation Regarding the Planet Mars.

Nov. 26th. Mr. W. R. Warner. Astronomical Photography.

Dec. 10th. Prof. C. F. Mabury, (not a member). Development of the Color Industry from Coal Tar Products.

Jan. 14th, 1890. Mr. A. Mordecai. Harbor Facilities for Cleveland, Especially for Handling Coal and Ore.

Jan. 14th. Mr. J. H. Sargent. A Belt Line Railway and Improvement of the Lake Front.

Feb. 11th. Mr. Edward Lindsley. Improvement in Railway Terminal Facilities, as Related to the Transfer of Coarse Bulk Freight.

Feb. 11th. Mr. James Ritchie. Requirements for Specifications for Steel and Iron.

Feb. 11th. Mr. M. W. Kingsley. Notes on the Water Works Tunnel.

March 11th. Mr. A. Mordecai. Progress in Railroad Engineering.

March 11th. Mr. C. G. Force. Progress in Civil Engineering and Surveying.

March 11th. Mr. Walter Miller. Progress in Mechanical Engineering.

March 11th. Mr. J. N. Richardson. Progress in Architecture.

The periodicals of the Club remain the same with the exception of the substitution of the *Electrical World* and the Architects' and Builders' edition of the *Scientific American* for two mechanical papers.

Respectfully submitted. C. O. PALMER, Secretary.

ANNUAL REPORT OF EXECUTIVE BOARD.

The Executive Board are pleased to report to the Civil Engineers' Club of Cleveland a most satisfactory condition of the Club in all its departments. The membership is larger than ever before, now numbering 135, an increase of 8 during the year. A large part of the membership is composed of men who are willing and ready to sustain the meetings by scientific papers on their various specialties, so that during the fiscal year just closed we have held 14 meetings, at which 21 papers have been read; many of which have brought out very interesting and instructive discussions.

Our Treasurer's report will show that careful work has been done in the Finance Department, for every member who lives in the city has paid his dues in full, and some of them in advance, and all the Club's bills to date are paid. In addition to this our subscriptions to Case Library are paid to July 1st, and the subscriptions to the *Journal of Engineering Societies* are paid to May 1st. We have a balance of $116.19 to turn over to the new administration.

The Executive Board would take this occasion to express their thanks to the many members who have so freely contributed to making the meetings a success.

Respectfully submitted, W. R. WARNER, President.

CLEVELAND, O., March 11, 1890.

To the Executive Board of the Civil Engineers' Club of Cleveland:

GENTLEMEN: I present herewith the annual report of the Treasurer of the Club for the year ending March 11, 1890, as follows:

RECEIPTS.

Cash on hand March 12, 1889, per last report	$ 16.33
Received from dues for past year (to March 1, 1890)	678.00
Received from dues for preceding year	51.00
Received from dues for ensuing year	12.00
Received from entrance fees	90.00
Total	$ 847.33

EXPENDITURES

For Journal of Association	$ 377.75
For subscriptions to Case Library	98.00
For room rent	75.00
For printing	84 70
For stenographer	39.50
For postage, and all other expenses	55.19
Total	$ 731.14
Balance in hands of Treasurer March 11, 1890	$ 116 19
	$ 847.33

The subscriptions to the Case Library, except a few fractional ones, are paid to July 1, 1890, and the assessment for the *Journal* is paid to May 1, 1890, and there are no unpaid bills that I know of, except for a few dollars' worth of printing for this

meeting, have not yet been presented, and one quarter's room rent is due April 1, 1890.

Respectfully submitted, S. J. BAKER, Treasurer.

Approved and accepted by Finance Committee.

HENRY C. THOMPSON, Chairman.
W. H. SEARLES.

On motion the reports were accepted. The tellers reported the ballot for officers, which resulted in the election of Mr. W. H. Searles for President; Mr. J. L. Gobeille, Vice-President; Mr. C. O. Palmer, Secretary; Mr. S. J. Baker, Corresponding Secretary; Mr. N. P. Bowler, Treasurer; Mr. C. M. Barber, Librarian, and Prof. Cady Staley, member of the Board of Managers of the Association of Engineering Societies.

Short speeches were made by the newly elected officers, and also by Messrs. Swasey, Leland, Eisenmann, and others.

By invitation of the President the Club was addressed briefly by Mr. G. W. G. Ferris, of Pittsburgh, and Col. Wm. H. Paine, of New York.

Adjourned. C. O. PALMER, Secretary.

ENGINEERS' CLUB OF ST. LOUIS.

318TH MEETING—SPECIAL.—A special meeting was held at the Washington University, January 17th, to listen to an address by Mr. T. C. Mendenhall, of the U. S. Coast Survey, on "Government Standards of Weights and Mass." There were thirty members and six visitors present. The address proved of great value and interest. WM. H. BRYAN, Secretary.

319TH MEETING—SPECIAL.—On the evening of January 18th, 1890, a complimentary banquet was tendered to Mr. T. C. Mendenhall, Superintendent of the U. S. Coast and Geodetric Survey. President Nipher in the chair. The following were present:

Guests invited by the Club:—T. C. Mendenhall, Henry Haarstick, M. S. Snow, and Arthur Winslow.—4.

Guests invited by individual members:—H. W. Parkhurst, Capt. Powell, H. S. Pritchett, O. W. Wheeler, and Mr. Marr.—5.

Members:—Jul. Baier, R. S. Colnon, G. H. Pegram, W. W. Penney, R. L. Van Sant, G. C. W. Belcher, E. A. Engler, C. W. Melcher, J. A. Seddon, E. C. Parker, W. H. Bryan, W. T. Gould, F. E. Nipher, L. Stockett, C. M. Woodward, Ed. Flad, M. L. Holman, J. A. Ockerson, A. Thacher, C. W. Clark, J. B. Johnson, R. H. Phillips, H. A. Wheeler.—23.

The toasts were as follows:—

"Our Guests"..............................	Response by....J. A. Seddon.
"The U. S. Coast and Geodetric Survey..	" " ....T. C. Mendenhall.
"Our Survey"..............................	" " ....Arthur Winslow.
"Our Coast"...............................	" " ....M. L. Holman.
"The School and the Engineer"...........	" " ....M. S. Snow.
"The Engineer of the Past"................	" " ....J. B. Johnson.
"The Engineer of the Future"............	" " ....C. M. Woodward.
"Our Waterways"..........................	" " ....Henry Haarstick.

The adjournment took place at 12:30 after a very pleasant evening.

WM. H. BRYAN, Secretary.

324TH MEETING, MARCH 19TH, 1890.—The Club met at 8:15 P. M. at the rooms of the Elks' Club. President Nipher in the chair; forty members and five visitors present. The minutes of the 323d meeting were approved as corrected. Applications for membership were announced from the following parties: Frederic Egner, Engineer Laclede Gas Light Company, endorsed by Emerson McMillin and W. H. Bryan; John J. Sanders, Assistant Engineer Missouri River Commission, endorsed by R. F. Grady and E. E. Wall; James A. Tiernan, Engineer with Robert Moore, Chief Engineer Merchants Bridge Terminal Railway, endorsed by Robert Moore and Julius Baier. These were referred to the Executive Committee.

Col. Meier, chairman of the committee on Ead's Monument, called attention again to the concert to be given at the Exposition and Music Hall on the 27th inst., for the benefit of the Monument Fund.

Prof. J. B. Johnson then read an address on the organization of a Federal Council of Engineers. The author, together with Messrs. Searles, of Cleveland, and Knight, of Kansas City, had at the recent meeting of the Board of Managers of the Association of Engineering Societies, been appointed a committee to prepare an address to the engineers of the country on this subject. The present paper was the result of the authors' investigations. A short time ago President Towne of the American Society of Mechanical Engineers, had addressed the leading engineering bodies of the country, including our association, suggesting a joint conference. This conference was to be simply provisional, and was not binding upon any of the associations or clubs. Prof. Johnson's address treated of the present status of engineers as compared with the members of other professions, and indicated some of the advantages that might result from a national organization. He gave an abstract of the qualifications required for membership in most of the engineering societies in the country, together with the number of full grade members, showing a total of over 5,000. The author thought that there were some features in the organization of the American Medical Association which might serve as a pattern. The author mentioned, as among the functions of a general organization, the establishment of a uniform grade of qualifications for admission; some attention to the education of engineers, and the class and rank of the degrees given by engineering schools; the proper use of the title "engineer"; some attention to the ethics of the profession; the formation of a general library; the establishment of permanent headquarters for engineers; the joint publication of proceedings and papers, as well as an index of general engineering literature; the awarding of medals for papers of value, and for engineering work of exceptional merit; the advocacy of state control over engineering structures; engineering representation on certain State boards, and in the direction of municipal works; the securing of Government aid in making tests of material; the establishment of standards of tests and shapes, and forms for making reports, the appointment of committees to investigate failures of engineering structures, as well as to report upon the success of new methods and structures; the entertainment of distinguished visitors, etc. The author believed that an organization of this kind would unify the interests of engineers, and mark a new era in the profession.

In the discussion Mr. Seddon stated that the subject was one of great interest and worthy of the most careful consideration. No two members would probably agree as to the details of an organization of this kind. He considered it proper that our Association should be represented in the proposed conference called by President Towne. His own view of the situation was that this Club was doing well as now situated, and while it should not be too conservative, it would be well to go slow in the matter, holding itself in readiness to take advantage of any general movement that might develop.

Col. Meier called attention to the different movements in this direction that had already been made, and thought that that of the American Society of Civil Engineers promised best results.

Robert Moore desired to know by what authority the Board of Managers of the Association had appointed this committee. He thought that some of the objections raised to a general organization were still unanswered, and he was not sure that the wider objects aimed at could be attained, or, if attained, would be found of much real value. He saw a decided difference between the profession of engineering and those of medicine and law, where general organizations served specific

purposes. He called particular attention to the fact that engineering in these days is not a single profession, but a dozen. The Committee of Conference, it should be remembered, was not official or representative, either as to the Association, or to the various Clubs.

Prof. Johnson, in reply, stated that the present action was not being taken by these committees as representing the sentiment of the engineering bodies of which they were members, but unofficially, simply with a view of mutual conference, with the possibility of developing some plan for future action, which might in due time be submitted for the consideration of the Societies.

Mr. McMath gave the result of previous efforts in this direction. He thought that such a council as proposed by Prof. Johnson would not be representative, but in time would be made up of aristocrats. He thought that if a general organization were ever reached, it must come in one of two ways: First, as a purely representative body; second, by absorption. In his opinion, the latter plan promised the best results. He was not sure that it was desirable that all who called themselves engineers, should unite. The interests to be considered were very diverse, and he thought it best to go slow. He was in favor of a thorough discussion of this question in the hope that something of value might be evolved.

Prof. Potter stated that the question was not what *might* be done, but what *could* be done practically, in the near future. He thought that this question was one of development, which in time would work out its own solution. He thought that a combined publication, and the adoption of certain standard units, were matters in which the various Engineering Associations might work together, and thought that it was not impossible to do effective work in this direction with the present organizations.

Mr. Ferguson thought it wise to go slow in this matter, but that it was equally important not to be too conservative. There was now a well defined movement in the direction of National organization. In his opinion, it was desirable that we maintain our position in the discussion.

Mr. Wheeler called attention to the experience of one of the National bodies where the diversity of interests had led to the division of the Society into eight or ten sections, each with its special work. These sections had found more to interest them in their special work than in the general organization, and some of them were withdrawing from the National body, and there was great danger of disintegration. This experience might be worth considering now. He thought the establishing of standards and the entertainment of visitors, were points upon which the Societies should co-operate, but that in his opinion, the formation of one general Association would result in such an incongruous mass, that its efficiency and stability would be doubtful.

Mr. Beahan considered this question one of growth and education. He saw no danger in the present general tendency towards National organization. He did not see the necessity of a "trademark" for engineers; neither did he see that it could do any harm. On the other hand, there was a possibility of considerable good, which might well be attempted.

Prof. Johnson stated that while it was true that there were many different branches of engineering, he still thought there were numerous questions of general interest, which would furnish work for a National organization. He called attention to the fact that the general public did not as yet recognize engineering as a profession.

Mr. Taussig stated that this was in a large measure due to the fact that engineers themselves did not insist on such recognition. In his opinion, this could be overcome by a combined effort of engineers individually.

Adjourned. WM. H. BRYAN, Secretary.

32[illegible]TH MEETING, APRIL 2, 1890.—The club met at 8:20 p. m. at the Washington University, President Nipher in the chair; thirty-five members and eight visitors present. The minutes of the 324th meeting were read and approved. The executive committee reported the doings of its eighty-seventh and eighty-eighth meet-

ing, approving the following applications for membership: Frederick Egner, John J. Sanders and James N. Tiernan. They were balloted for and elected.

Mr. Thos. J. Long then addressed the Club informally on the erection of some recent large bridges. The address was illustrated by lantern slides, showing interesting features of the prominent bridges discussed. A number of slides were devoted to the St. Louis Merchant's bridge, just completed. The last span of this bridge was erected in less than sixty working hours, being the shortest time on record for a double track bridge. The large bridge recently erected across the Ohio river at Cairo, was described. A span of this bridge was erected in forty-five working hours, being the shortest reported time for a single track structure. Among the other bridges described by the author were those at Hawksbury, Australia; C. Shaler Smith's cantilever bridge over the Kentucky river; the Niagara cantilever bridge; another cantilever bridge over the Kentucky river; the Hudson river bridge at Poughkeepsie; the Forth, and Tay bridges, the specially interesting features of each being explained. The Club expressed its appreciation of the address by applause.

Mr. Frank Nicholson's paper on "The Pemberton Concentrator" was then read by Mr. Arthur Thacher. The author explained the difficulties met with in concentration, and stated that there was a widespread opinion that concentration under any circumstances was of doubtful value. The writer explained the Pemberton concentrator, which was of a new design, and appeared to have advantages in simplicity and requiring no power. Its working was explained in detail and illustrated by a drawing.

In the discussion, Mr. Wheeler took issue with the author on the subject of the efficiency of concentrators. He stated that a large number were in regular and successful operation, and cited instances bearing out his statement. Many low grade ores were being profitably handled with concentrators, which could not be worked at all without them. He considered the Pemberton apparatus strictly speaking, a hydraulic classifier, and not a concentrator. He also stated that in general, the fine material should not be sized. He thought the Pemberton apparatus would save water, and that it also had some other points of merit, but it was in many other respects inferior to the latest types of classifiers.

Mr. Thacher thought the author, in stating his opinion as to the efficiency of concentrators, had reference principally to stamp mills, and did not have reference to the Eastern mills. He also called attention to the fact that the profit claimed to be realized by this concentrator would probably be largely reduced by other necessary expenses in working up the ore.

Adjourned. WM. H. BYRAN, Secretary.

MONTANA SOCIETY OF CIVIL ENGINEERS.

REGULAR MONTHLY MEETING, FEBRUARY 18, 1890.—There were present Messrs. Haven, de Lacy, Sizer, Pearis, Foss, Wade, and Canse. In the absence of the president and vice-president Mr. Haven called the meeting to order.

The minutes of the annual meeting were read and approved.

Applications for membership were received from N. J. McConnell and Samuel D. Bridge, which were referred to the Secretary for letter-ballot. Messrs. O. C. Dallas, Frank D. Jones, James L. Buskett and Findlay McRae were elected members of the Society.

The following were designated as standing committees for the ensuing year: Committee on Public Works, Committee on Affiliation with the American Society of Civil Engineers, Committee on Public Land Surveys, Committee on Library, Committee on Topics. The president to appoint the members thereof at his convenience.

The trustees having audited the reports of the secretary and librarian, and treas urer for 188 , the same were approved.

Mr. Sizer of the committee appointed to confer with the Hon. Thomas H. Carter on the subject of the revision of the U. S. Mining Laws, made an interesting report of progress; the committee was continued to make final report at next meeting.

An amendment to the by-laws changing the annual dues of resident members to $10 0 and non-resident members to $8.00 per year was carried.

The secretary was ordered to have printed in pamphlet form 1c0 copies of the Societies' letter to the Hon. Thomas H. Carter on the subject of Public Land Surveys.

Adjourned. CHARLES G. GRIFFITH, Secretary.

WESTERN SOCIETY OF ENGINEERS.

MARCH 5, 18 0.—The 267th meeting of the Society was held at its rooms on Wednesday evening, March 6th, President L. E. Cooley in the chair, with some thirty-five members present.

The Secretary having been advised of an error in the printed report of the last meeting, wherein it was stated that the President was authorized to appoint certain committees recommended by him, before approving the minutes a correction was ordered to be made.

The report should have stated that the motion was carried "that the whole subject be made a special order for the meeting of March 5.

The Secretary reported that nothing new had come before the Board of Directors, but that the following gentlemen had been elected to membership: John B. Hittell, Wm. J. Karner, Henry W. Yung, Edwin W. Jackson, James P. Coleman, Hugh L. Cooper, E. W. Stearn, John A. Jackman, Chas. R. Schniglau, Ira Harris, Julius Hegeler, D. J. Barnes, Jas. H. Dinwiddie.

The following applications for membership were also received. Curtis Dougherty, Chas. R. Wightman, Geo. K. Wheelock, C. D. Hill, Fredk. S. Brown, Egerton Adams, William Lee, Chas. F. Brown, C. McLennan, H. G. Taylor.

The President then called for reports of committees, and receiving no reply, proceeded to the business of the evening—made a special order by vote at the last meeting—the consideration of the appointment of committees on the several subjects recommended by him.

Mr. Cooley very briefly presented the business of the meeting, after which the Secretary read a communication from Mr. C. L. Strobel, in which he advocated the discussion of each of the topics separately upon which committees were proposed, and opposed committing the Society to any action savoring of a political character.

Mr. Cooley suggested, by way of comment, that the communication misapprehended the purpose of the appointment of the committees.

Mr. S. G. Artingstall favored the consideration of each committee separately; advocated the continuation of the committee on National Public Works, and discussing that on Bridges, deprecated the idea of the Society interfering whatever in politics. He had no objection to a committee on bridge legislation, but considered that for the committee to mature and report a bill would have no influence, and as work was of no good to the Society. It was well for the members to express their individual opinions on such a subject but the Society would do wrong to endorse the action of a committee. The Society did not want to be responsible for member's opinions, as it would be by affirmative action on committee reports. Hence care should be taken in apportioning work to a committee.

The question of considering the topics separately being put to vote, it was ruled in the affirmative.

The continuation of a committee on *National Public Works*, being Topic No. 1, was voted upon and carried without discussion.

No. 2. *Bridge Legislation.* Mr. W. E. Williams opened the discussion by refer-

ring to the condition of the profession that has prevailed in this country in comparison with Europe. For all accidents here the profession is blamed, when in point of fact engineers have no real authority in the premises. This condition is due in a measure to lack of effort on the part of the profession. He considered that it was eminently proper that the committee should report upon and frame a bill, and that the Society should consider it and endorse it if it covered the question. He could not see where the politics came in so far as the Society was concerned.

Mr. Artingstall reinforced his former arguments, and moved that the wording of the resolution should be changed to read that the question of the conditions and safety of railway and highway bridges should be brought before the Society for discussion and consideration.

The President drew the attention of the speaker to the question that the President be authorized to appoint a committee of five on each of the topics named, to report in November, and that these committees would have no authority but to report to the Society. He saw no objection, however, to amending the proposition.

Mr. Geo. W. Waite amended to appoint committees without instructions.

Mr. Gottlieb, who was a member of the former committee, explained what that committee had done and the difficulties it had to contend with. The railway question was a difficulty in the way; to do justice to all interests, and finally to obtain action, was a work requiring much time and immense labor. He could not see wherein would be the good of appointing a committee without instructions.

Mr. W. E. Williams contended that the railway and highway interests could be separated. He referred to the railway commissions of various States. He fully believed in the Society taking up the question and making recommendations as to the law.

The Secretary did not consider the debate was taking the right line; he could not understand where the Society was committing itself to politics by appointing a committee to consider so important a question as bridge construction and regulation, even should it be authorized to mature a bill. Should the Society endorse the committees' work, there it ended as far as the Society was concerned. It was a matter of public interest over which the profession should exercise authority.

Mr. Purdy said that we should know all the facts in connection with so important a matter, and that such a committee he hoped, would be able to present such to the Society. After obtaining all this information, whether the Society should exert its influence in favor of a bill or not, could then be intelligently considered.

After some further discussion the proposition was amended to read as follows, was put to vote and carried:

2. *Bridge Legislation.* Reconstitute the committee. This committee was discharged last year. It is proposed to appoint a new committee to mature a report in regard to the regulation of the construction and maintenance of highway and railway bridges in the interests of public safety.

On No. 3. *Practice of Sanitary Engineering.* Mr. Artingstall opened the debate by presenting the same objections as before on general principles. He also drew attention to the amount of work required to get together the proper information. Every individual town and village had to be treated and considered separately.

To facilitate reaching a vote the proposition was amended to read as follows:

3. *Practice of Sanitary Engineering.* A new committee to report in regard to the regulation of the practice of Sanitary Engineering in the interests of the public health, with a view of preventing the carrying out of faulty, inadequate and unsanitary plans for sewerage and water-works.

A vote was taken and the proposition carried as amended.

No. 4. *Municipal Public Works.* Mr. Artingstall suggested that no committee be appointed on this subject at all.

Mr. Gottlieb drew attention to the fact that different methods existed in different cities, and considered that the committee could give the Society a fund of information, but that the Society could not prescribe to cities how they should govern themselves, but could express an opinion.

Mr. Waite believed in appointing such a committee.

Mr. O. Guthrie described some points which had been forcibly presented in Chicago in recent years, and suggested that Municipal Public Works would afford scope enough for a wide-awake committee to be of much service on the subject.

After some further remarks the proposition was voted upon and carried in its original form, as follows:

4. *Municipal Public Works.* A new committee to recommend a proper organization for public works in cities of the first class; and also for smaller municipalities.

On No. 5. *Topographical and Cadastral Survey for Illinois*, there was an unanimous sentiment of approval. The discussion, which was general, brought out considerable experience in the difficulties and differences of matters as they now stand and the general good arising from an authentic survey was acknowledged.

The proposition was put to a vote and carried in its original form, as follows:

5. *Topographical and Cadastral Survey for Illinois.* A new committee to report upon the utility and expediency of inaugurating a topographical and cadastral survey for the State of Illinois.

The President said he would announce committees in proceedings. This practically closed a long and interesting evening.

Adjourned. JOHN W. WESTON, Secretary.

The President announces the following committees, in accordance with the action of the Society:

1. *National Public Works.* Messrs. L. E. Cooley, E. L. Corthell, H. B. Herr, E. C. Shankland. Fred Davis.

2. *Bridge Legislation.* Messrs. O. Chanute, E. C. Carter, Wm. F. Wallace, Maurice Seifert, Wm. E. Williams.

3. *Practice of Sanitary Engineering.* Messrs. A. V. Powell, J. W. Alvord, Wm. Hoskins, Edgar Williams, Urban H. Broughton.

4. *Municipal Public Works.* Messrs. Benezette Williams, S. G. Artingstall, W. R. Northway, H. C. Alexander, John A. Cole.

5. *Topographical and Cadastral Survey for Illinois.* Messrs. L. L. Wheeler, C. McLennan, F. G. Rossiter, B. Feind, W. T. Casgrain.

BOSTON SOCIETY OF CIVIL ENGINEERS.

MARCH 19, 1890.—The annual meeting of the Society was held at the American House, Hanover street, Boston, at 9:50 o'clock. President FitzGerald in the chair. Forty-five members and forty visitors present.

It was voted to dispense with the reading of the record of the last meeting.

Messrs. David A. Harrington, John L. Howard, Clarence A. Perkins and Frank H. Snow were elected members of the Society.

The Secretary read the annual report of the Board of Government, which was accepted and ordered printed.

The Secretary read an abstract from the report of the Treasurer. The report was accepted and an abstract ordered printed.

The annual reports of the several special committees were then presented, and on motion of Mr. Howland, it was voted: That the several reports be received and their consideration assigned to the next meeting. The Government was also authorized to print and distribute, previous to the April meeting, such of the annual reports as seemed advisable.

On motion of Mr. Brooks it was voted to continue all of the special committees as now constituted until the next meeting.

Mr. Spalding, for the tellers appointed to canvass the letter-ballots for officers, announced the result. There being no choice for President or Director, the meeting proceeded to choose from the two candidates for each office having the highest number of ballots. As the result of the letter-ballot, and choice of the meeting, the President declared the following officers elected: President, Clemens Herschel; Vice-President (for two years), John R. Freeman; Secretary, S. Everett Tinkham; Treasurer, Henry Manley; Librarian, Frank W. Hodgdon; Director (for two years), Frederick Brooks.

The President then introduced Mr. Cope Whitehouse, of New York, who addressed the Society on the Raijan Project for an escape canal and storage reservoir:

Genius, he said, in the French language has been for the last four centuries used of the profession of engineering so that "*genie*" is equally the inspiration which excites to daring flight, the poetic fancy, and that "sublime common sense" which spans the Forth. The word has been degraded in English by its limitation to natural qualities, to the exclusion of him who traces his career by some memorable and enduring change in the physical aspect of the earth. Tennyson, however, has made Merlin, "the most famous man" of all those times of mediæval romance, an engineer first, and a bard and astronomer only as subordinate to practical achievements. This is the prevailing feeling in the United States.

The poets were fond of claiming an immortality for their words which was denied to deeds "however nobly done." It was his task to-night to show them that, before Homer, there was an epic, written in water and sand; a picture painted upon 5,000 square miles of surface; a series of sculptures where millions of tons of rock were used to convey an idea, and that idea so nobly and so wisely adapted to human needs that eye and ear would not be able to catch more than intimations of the vast engineering work, which connected the name of Joseph—patriarch and engineer,—Pontifex-Maximus, founder of the first *ecole des ponts et chaussees*, on the banks of the Nile, with the largest canal, probably in the world. After a life of 4,000 years it is now to give birth to fresh works, in part new canals for neglected and abandoned provinces, following the old lines traced by that master mind, centuries before Moses showed to Pharaoh the plagues which would be inflicted upon Egypt by interference with the great scheme for regulating the flow of the Nile through Middle and Lower Egypt.

Aided by stereopticon views Mr. Cope Whitehouse started with an ancient map of Egypt, preserved in the Monastery of Mt. Athos, and showed how a little spot of color "no bigger than a blot" had gradually expanded and been defined by his researches until it was now the best surveyed area of unoccupied territory in the world. The facts therefore were no longer open to dispute. The recent book of Mr. W. Willcocks, on Egyptian Irrigation, contained the details of the engineering works, with the estimates of cost and profit. Without accepting Mr. Willcock's figures which had been purposely kept by him on the safe *official* side, it might be said that the *floods* of the Nile could be controlled by an *escape* 300 feet wide and seven miles in length, at a cost of $4,000,000, communicating with the depression he had discovered.

The regimen of the Nile is remarkable for its great regularity. The extreme difference between the highest and lowest high-Nile in 126 years was only 10 feet. The sudden, accidental and unexpected rises of our rivers never occur. The rise is fixed in time to one annual period. The danger, however, from disastrous flood is always recurring because the river is confined with so small a margin, that it is said that in critical years four inches have been sufficient to determine a great disaster. A high flood is a scourge. It invariably leads to the loss of the summer crops. It may easily cost the country $10,000,000. Hence the necessity and value of the Raijan Escape.

The *mean* low discharge of Nile is 16,800 cubic feet per second at Assuan, where the river enters Egypt. It sometimes falls to 9,600 cubic feet. The total requirements of Egypt are 93,000,000 cubic meters per diem, or 37,200 cubic feet per second. Egypt, therefore, is reduced to a total *summer* area, which is little more than one-half of the possible cultivation. Two million three hundred thousand acres of unreclaimed lands are absolutely sterile. Four million nine hundred and fifty-five thousand acres represent the total cultivated area. The summer cultivation is based upon a mean normal supply. There is always waste: either of crops lost for want of water, or land left uncultivated from fear of an insufficient low-Nile. The remedy for this is the storage of a part of the flood in the "Moeris" reservoir. The earthworks, masonry works, and land (in the Nile Valley) cannot cost,—according to Willcocks,—more than $7,945,000. He allows for about 25,000,000 cubic yards of earthwork, and $1,072,500 worth of masonry, bridges, etc. This includes the cost of the Canal of Escape.

The storage reservoir would have an area of 250 square miles, a depth of about

225 feet, contain 20,500,000,000 cubic meters of water, or say 5,000,000 million gallons. The stratum available without pumping would be the difference between high and low Nile, say 25 feet, less about 1½ feet evaporation after the inflow ceased, but increased by feeding the Raijan Escape through the Bahr Jusuf and Ibrahimieh Canal, and utilizing the water by a canal which would shorten the distance to the Barrage and draw the lake down below the level of low-Nile, opposite the mouth of the Raijan Escape, used also as a canal of discharge.

Thus the Raijan Escape and Moeris reservoir would effectually control the Nile in flood and drought, and by relieving the present population from part of their labor, and creating new provinces in the north of Egypt, make Egypt once more the most pro perous country in the world. It is a challenge to the nineteenth century. The British-Indian irrigation engineers have thus far contented themselves with wasting years in perfecting surveys, and drawing up reports on a project, which as they themselves concede, "has no rival," while they have not, as yet, displayed sufficient energy to turn to account the splendid provision which nature offers them, and history guarantees.

The British control of the Irrigation Department has disappointed its most indulgent critics. It claims that "in the last five years it has repaired the Barrage; made a commencement of drainage; set the older canals and their works in efficient working order, and improved the basin regulation." (Col. Ross.) These marked results bear no sort of proportion to the means at the disposal of the British-Egyptian Administration of the country. "There still remains to be done: the completion of the basin works for red-water supply; the extension of drainage channels; economies in distribution of summer water. These will be finished by the new loan in three years and then the great question of storage of water for summer can be taken up." (Col. Ross.)

Even if the actual execution of the Raijan project should be postponed for three years, these researches need not be fruitless. The challenge offered by "King Mœris" nearly 4,000 years ago may be met in the United States. The American problems in irrigation and flood control are in every way more formidable than the Egyptian. The factors are more numerous. The figures are larger. The constants are fewer. The variables have greater range. The areas to be affected are a hundred times more extended. It may be that we shall construct a larger escape and store a greater volume of water in the Valley of the Mississippi and the Rio Grande, but it will require a similar close study of nature and equally skillful use of natural resources, if the life of our works is to be estimated at thousands of years, and our dams and canals in working order are to gain the admiration of engineers in A. D. 6,000, as Mœris received unstinted praise from Greek and Roman 1,800 years after Joseph had been buried amid the lamentations of the nation which he had rescued from flood and famine.

At the close of the address the President said that much interest had been manifested in Mr. Cope Whitehouse's theory in regard to the construction of the two great pyramids at Gizeh, as presented by him to the Am. Soc. of Civil Engineers at the meeting in Buffalo. The Boston Society would be glad to have fuller details upon these exhibitions of ancient engineering skill.

Mr. Whitehouse said that at an early stage in his investigations he was satisfied that the pyramids—as a class—bore a topographical relation to the Fayoum and Raijan depressions, which could not be accidental. All the pyramids of Egypt lie between the Fayoum Canal and the apex of the Delta. This long line of over sixty miles prohibits their exclusive association with Memphis as a great centre of population and power. Why, too, were no other cities in Middle Egypt provided with similar monuments? Why were no pyramids raised in the plains of the Delta?

The modern engineer when required to raise a monument begins by digging a hole. The ancient engineer carved a temple at Abu-Simbel, on the Upper Nile, and a Sphinx at Gizeh out of the solid rock. As the Dept. of Public Works in B. C. 1800 had utilized a natural depression to make a reservoir, while modern engineers had proposed a dam across the Nile, so it would have been in harmony with ancient modes of thought and engineering principles to take what nature had given them and adopt it, rather than to erect an immense cairn, with such an appalling disproportion between labor and result that the pyramids were always cited as a proof of an unenlightened exercise of human force. Using about twenty lantern slides, sec-

tions, diagrams and views from various points, he showed that as the summits of the two pyramids are not as high as the adjacent hills, it is a tenable hypothesis that they are the revetted natural summits of the hills on which they stand. The only excavation *in* (not *under*) any pyramids is in that of Cheops. It is of insignificant dimensions as compared with the two huge masses of Gizeh, or the almost equally large pyramids of Dashour. The stones appeared to have been moved downwards, and confirmed the opinion that as the modern engineer, cutting away the base of a hill in horizontally stratified rock, often revets the slope by stones quarried on the hill above, so these engineers had revetted four sides of a hill from a point, thus converting a precipitous, flat-topped, irregular butte into the broad-based, stable mass, which then would no longer disintegrate under atmospheric influence and endanger, by falling stones and sand, the occupation of the terrace, which these structures still shelter from sun and wind. Some of them might then be used with propriety as places of sepulchre for a Pharaoh. It was certainly not the case that all had been employed for this purpose.

After passing a vote of thanks to Mr. Whitehouse for his interesting and instructive lecture, the Society adjourned. S. E. TINKHAM, Secretary.

ANNUAL REPORT OF THE GOVERNMENT OF THE BOSTON SOCIETY OF CIVIL ENGINEERS.

In accordance with the requirements of the Constitution, the Government submits the following report on the affairs of the Society.

Your Treasurer's report shows a net gain of $81.64 to the funds of the Society. It should be said in explanation that the Atchison, Topeka & Santa Fe bond which has been reckoned in the past at its par value has been sold the past year, netting the Society but $731.81. Your Librarian reports the addition of about sixty-five volumes to the Library.

At the last annual meeting our total membership was 219, four honorary and 215 active members. During the year now ended we have lost, by death, one, by resignation one, and four names have been dropped from the list, making a total loss of six. Twenty-four members have been elected during the year, making a net gain of eighteen. Our list at this meeting comprises four honorary members and 233 members, a total of 237.

Ten regular meetings and one adjourned meeting have been held during the year. The annual dinner being this year at last a separate gathering. At the regular and adjourned meetings, the attendance has aggregated 522 members and 126 visitors, a total of 648. The smallest attendance at any meeting was 40, and the largest 8[illegible], the average being 59. The attendance at the annual dinner was 117, the largest that we have ever had.

The following papers have been read at the several meetings: March—Address by President FitzGerald, illustrated by lantern views. April—Memoirs of Samuel M. Felton and Edward S. Philbrick, Submerged Railroad Embankment by L. B. Bidwell; An Account of the Proposed Terminal Facilities at Providence, by Samuel M. Gray. May—High-service System of the Boston Water-Works, by J. A. Gould, Jr.; Experiments on the Flow of Water Through Large Gates, by C. E. Haberstroh. June—Algæ Growths in Water Supply, by F. F. Forbes. September—Mills and Mill Engineering, by Edward Sawyer, with interesting discussions by a number of experts. Prudence in Pillar Design, by J. R. Freeman; Memoir of William S. Barbour. October—Notes on European Travel, by Messrs. Leavitt, Barrus, Freeman, Brooks and Tilden. November—Freezing Process of Making Excavations by Mr. E. L. Abbott, of New York. December—Heating and Ventilating School Buildings (three papers), by W. E. McClintock, T. P. Perkins and Prof. S. H. Woodbridge of the Institute of Technology. January — Filtration of Natural Waters, by Prof. Thomas M. Drown, of the Institute of Technology. February—Transmission of Power by Electricity, by Capt. Eugene Griffin.

During the year the Society has passed very successfully through the trying ordeal of revising its Constitution and By-Laws. Among the important changes there is but one to which the Government cares at this time to refer. The new class of membership introduced, that of associates, provides a means for persons, not engineers by profession, to join the Society. In the past there have been a num-

ber of men, who, deeply interested in engineering subjects and enjoying our meetings, would gladly have associated themselves with us if there had been any suitable grade for them in our membership. The Government hopes at the close of another year to see a goodly number of names on our list of associates.

Upon resuming our meetings after the summer vacation, we were compelled to seek new quarters: thus far it has not been possible to procure rooms which satisfactorily meet our wants. The present arrangement cannot be considered at all permanent. As the Standing Committee on Common Headquarters is soon to submit a report for the consideration of the members, the government have thought it unwise to refer to the matter in any other way than to express the hope that out of the consideration of the question by the members, some definite plan may be adopted without more delay than is necessary to secure the best action.

It is our sad duty to record the death of Lincoln Cabot, which occurred at Honolulu, Sandwich Islands, on Dec. 14, 1889. Mr. Cabot joined the Society June 8, 1874, and continued his membership without interruption to the date of his death.

Respectfully submitted, on behalf of the Board of Government,

BOSTON, March 19, 1890. DESMOND FITZGERALD, President.

ABSTRACT OF TREASURER'S REPORT FOR THE FINANCIAL YEAR 1889–90.

CURRENT FUNDS.

Income.

Cash at beginning of year	$174 80
Non-resident dues, 1889–90	32 00
Non-resident dues, 1890–91	8 00
Assessments levied March 20, 1889, 168 members at $6 00	1008 00
Dues from new members (admitted since change in Constitution) four at $3 00	12 00
Journal for new members	3[illegible] 50
Subscription for portraits of Presidents	81 75
Interest on deposits	14 41
Sales of Journals	5 75
Sale of furniture	10 00
	$1383 21

Expenditures.

Association of Engineering Societies Journal for eleven months	$583 25
do. Expenses managers' meeting	43 49
Library, binding and periodicals	37 65
Printing, postage and stationery	214 79
Secretary's salary	100 00
Annual dinner	29 50
Portraits of deceased past Presidents	81 75
Stenographer	3[illegible] 6[illegible]
Expenses of meetings, rent, janitor and lantern	25 00
Furniture	3[illegible] 50
Loaned to permanent fund	11 88
Cash on deposit	177 50
	$1383 21

PERMANENT FUND.

Receipts.

Cash at beginning of year	$421 06
Twenty-five admission fees (less $4 abated	236 00
Sale of A. T. & S. F. Bond	731 81
Interest and dividends	99 25
Borrowed from current fund	11 88
	$1500 00

Expenditures.

Loaned on mortgage of real estate	$1500 00

Schedule of Funds of the Society, March 18, 1890.

One Republican Valley Railroad, 6% non-exempt bond No. 2, par value	$600 00
Nine shares C. B. & Q. stock par value	900 00
First mortgage on real estate	1500 00
Cash	177 50
	$3177 50
Schedule presented at last annual meeting	3095 86
Net gain	$81 64

HENRY MANLEY, Treasurer.

ASSOCIATION OF ENGINEERING SOCIETIES.

ORGANIZED 1881.

Vol. IX. May, 1890. No. 5.

This Association, as a body, is not responsible for the subject matter of any Society or for statements or opinions of any of its members.

ADDRESS ON RETIRING FROM PRESIDENCY OF THE WESTERN SOCIETY OF ENGINEERS.

BY E. L. CORTHELL, MEMBER WESTERN SOCIETY OF ENGINEERS.

[Read January 8, 1890.]

Members of the Western Society of Engineers and guests: It is the custom for retiring presidents to deliver an address upon the engineering progress of the age, or of the ages, to show what advance has been made by our profession in adapting the laws of nature to the wants and convenience of man. It is hoped that a departure from this usual course will not be a disappointment to you. It is proposed to briefly state the conditions in which we are placed as members of this Society and the demands upon us for professional work, and then to describe briefly some of the engineering works of the world, not only those that have been completed and are monuments to the genius of those who have conceived and executed them, but of other works now in process of construction and of still other works that are simply projects as yet, but likely in the near future to be realized in actual construction.

It would be difficult to find any section of our great country where there are greater demands upon the Civil, Mechanical and Electrical engineer than that section of the country of which Chicago is the central point. Perhaps nothing will bring this out more vividly than a summary of a statement recently prepared to show the importance of this city as a

transportation centre, a place to receive and dispatch goods and to move great masses of people.

Total length of main lines with terminus in Chicago	54,411
Tons of freight received and forwarded during 1889	43,013,444
Number of passengers handled during 1889	18,070,495
" " " " per day	48,965
Suburban passengers handled during 1889	10,759,108
Total length of street car lines in miles	115 2-10
Number of passengers handled by street car lines (1889)	163,000,000
Average per day	446,576
Tons of freight received and forwarded Chicago port (1889)	8,900,000
" " " " " " Ills. & Mich. Canal	790,375
Number of passengers that can be handled by the railroads and street railways per day 3,210,000 per hour	170,835

44,951 car loads of freight can be handled daily in Chicago freight yards.

When it is remembered that the vast system of railroads which does the immense business stated in this summary has mostly been built within the last 30 years, and that every mile of it was staked out and built by an engineer, the importance of our profession in this great branch of commerce will be appreciated. Along the lines of these railroads and in the heart of the city, itself, to which they lead, have been built up, through the facilities which they furnish, great and varied industries. To this port there comes and goes a freight tonnage as great as any city in the world, not excepting Liverpool. Piers, docks, elevators, harbor works, all are necessitated by this transportation business by rail and lake. The river which meanders through the heart of the city requires bridges and tunnels for crossing it, and that same river (if it be a river) receives the sewerage of nearly a million inhabitants and yet has no natural outfall except into the lake whose waters these inhabitants drink. This state of affairs in a city growing like ours has led to a development of plans and nearly to their realization which will not only, when carried out, remove from us, through the purifying influence of a great body of fresh water flowing towards the Mississippi river, the sewerage of the city, but will also furnish an enlarged water transportation between the great lakes and the Gulf of Mexico. Here certainly is a field for the highest class of engineering—here are difficult problems in hydraulics and in construction which are presented for immediate solution.

Let it be also remembered that the metropolitan district of Chicago has not attained its growth—far from it—that growth is still phenominal among the cities of the north, it being estimated by statisticians that the rate of growth at the present moment is 900,000 per decade with an increasing increment. No one can forecast the future or predict the magnitude of the city where we have cast our lot as engineers, nor can any one measure the possibilities which are before us as a Society of engineers. Certainly these conditions so important and so grand in their future results demand of us not only to give ourselves to the engineering problems as they come rapidly following each other, but that we should organize ourselves as professional engineers into a society in order that we may be the better able to discuss, to solve and to successfully handle the problems as they are presented.

It is a satisfaction to know from the report of our Secretary that the

Western Society of Engineers, whose headquarters are in this city, is not in a moribund condition, but in one of active growth, for his report shows that the increase in membership during the last year has been 40 per cent of the entire membership at the beginning of the year, and it is safe to say that this membership is an active one; that there is no dead wood in it; that the men who have joined this society during the last year have done it with a purpose and that purpose has been two-fold no doubt; first, to promote the general interests of engineering in the city and in the country tributary to it; and, second, to promote their own individual growth and usefulness as engineers. This society has arrived at that point where there should be only active membership and where every one should take hold in earnest to make the Society with its meritorious objects an eminent success and of great usefulness in the important section of the country where it is placed.

It is safe to predict that this Society will make its mark, and that broad and deep, in the progress which this city is bound to make in the future, and it is our duty to prepare ourselves for our work by strengthening our borders, by perfecting our organization in every possible way and by each one taking up the duty that devolves upon him as a member of the Society and faithfully performing it.

The subjects which we discuss should be live subjects, those pertaining to the great engineering wants of our country and of our city. More papers are needed from the membership. All of us have some experience in our work. We have accomplished something, the relation of which will be of interest and profit to the others, and hardly any subject which involves the construction of public works can be described without illiciting discussion, which in itself will be of advantage. A most earnest appeal is therefore made to the Society to bring forward for information and for discussion the results of experience, the results of thought and of plans which have been carried out or which exist only in the brain of the engineer.

We wish it also understood, not only among ourselves and with our guests who honor us with their presence to-night, but throughout the city and section of country where our membership reside that all intelligent men who are interested in engineering and constructive questions and works, and who desire a membership with us are welcome here. Our meetings for the reading of papers and discussions are also open to all who have a desire to attend. And should our rooms become so contracted by our increasing membership and by the growing interest in our discussions that we cannot conveniently take care of those that come, we will have sufficient reason for enlarging our borders.

With these general remarks pertaining to our city, our Society and to our engineering conditions we desire to interest, and we hope to entertain you as well, by describing and illustrating by lantern views some engineering works selected, some of their novelty, some of their peculiarities of foundations, some for their grandeur and some because of a personal acquaintance with them and so better able to describe and illustrate. Some of these descriptions have been obtained directly and quite recently from engineers who built the works, some of them from histories of the works and from

engineers and others connected with them both in this country and in Europe who also have been kind enough to send the photographs from which the lantern views have been made. The views of these works, as they appear one after another on the canvass, should serve to stimulate us as engineers to great things—to surpass, if we can, the works here shown, some of which are by the masters in our profession. We should be unwilling simply to follow in their footsteps. The increasing demands of commerce should lead us to dare still greater things—to undertake still greater works than those which will appear before you this evening. Practically there is no limit to the greatness and the grandeur of the works of our profession. We should not only imitate the men who have built these great works, but we should study to originate and to develop in order that we may surpass them, with this great object always in view of doing it all to promote the welfare of our fellow men.

LIVERPOOL DOCKS.

The docks of Liverpool on both sides of the Mersey are under the same trust and management. On the Liverpool side they extend along the Estuary 6¼ miles. The Birkenhead docks have less frontage, but extend a long way backward. The water area of the Liverpool docks and basins is 333½ acres, with a lineal quayage of 22 miles. The Birkenhead docks contain a water area of 160 acres with a lineal quayage of 9 miles. The system of floating docks was commenced by the corporation in 1709. In 1856 the control was taken from the corporation and the management vested in the Mersey Docks and Harbor Board, consisting of twenty-eight members. Since 1880 the annual revenue has been over $6,000,000. In addition to the floating docks, there are in Liverpool eighteen graving docks and two gridirons. In Birkenhead three graving docks. In 1860 the number of vessels entered in Liverpool was 4,746 with a tonnage of 450,060. In 1880 vessels entered 20,249, tonnage 7,933,620. In the number of ships registered as belonging to the port, Liverpool stands first in the world. The size of the ships has greatly increased, having reached 10,000 tons burden with 20,000 horse power.

MENAI SUSPENSION BRIDGE.

Near Bangor, North Wales, the mainland is separated from Anglesea Island by the Menai Straits. A bridge over these straits was built by Thomas Telford, civil engineer.

Active construction was begun in 1820. On the Bangor side of the Strait solid rock was found at a depth of seven feet. There are three arches on the east side and four on the west, or Anglesea side. The construction of these arches required four years. The piers were 65′ high from high water line to the swinging of the arches, the span of each arch being 52′ 6″. The two principal piers for the suspension of the main chains were 153′ in height.

The central portions of the main chains were built on a raft 450′ long and 6′ wide floated to the bridge site and lifted in place by capstans and tackle. The capstans for hauling in the ropes bearing the main chains were manned by 150 laborers, showing how crude were the appliances

with which the engineer was compelled to work even on such a stupendous work as this was for those times. The engineer had no past experience to guide him in designing his iron work. The failure of the bridge was predicted and it was freely spoken of as "a castle in the air". Total length of the bridge is 1710′, the distance between points of suspension of the main bridge is 579′, the main chains are 16 in number deflecting 37′ each, composed of 36 bars of ½″ square iron placed so as to give a square of 6″ on each side. Total weight of iron 2,187 tons in 32,265 separate pieces. The cost including embankment, half a mile of new road and toll houses was $600,000. The bridge was opened for traffic January 30, 1826.

BRITANNIA BRIDGE.

The Britannia bridge crosses the Straits of Menai. The bridge consists of two independent continuous tubular beams each one being 1511 feet long, weighing some 5,242 tons, not including cast iron pedestals. A single track through bridge of two spans 460′ each and two 230′ each weighs 1,800 tons, about one-third of what the single track Britannia bridge weighs.

The bridge is divided into four spans, two of 460′ each and two of 230′ each. The distance between shore lines at high water mark is 1100 feet. The first stone was laid April 10th, 1846, and the bridge was finished March 5th, 1850. The substructure consists of two abutments and three piers. The center pier is known as the great Britannia tower, It is 230′ high and is built on a rock in the middle of the Strait. The masonry is massive rather than beautiful. The two side spans over land were built on falsework in exact position; the two middle spans were erected on wooden platforms at high water on shore and floated into position between piers. These spans were placed on rests cut into piers near high water line and then raised by hydraulic jacks into position. The first big tube was floated on pontoons June 19th, 1849; the last tube was floated December 3rd, 1849, and set in its permanent position January 7th, 1850. The long spans weigh about 1,718 tons each; the clear width of roadway in tubes is 15 feet; the clear height 23 feet at ends and 30 feet at center of span. The tubes are fixed on the center pier and have roller bearings on other piers and abutments. Some 1,008 tons of rivets (fully 2,000,000 rivets) were used in the bridge. The total cost of the structure as built is $1,172,250. The structure was built by Robert Stevenson, his father George Stevenson being consulting engineer.

The difficulty of raising such immense structures as these to so great a height with such appliances as were available at that time was very great and in one or two instances accidents happened which threatened to bring destruction upon the work, but it was avoided by the extraordinary precaution and great detailed care which was taken by the engineer in all of his plans and appliances. The history of this work and of this man, of his father and of other great engineers of that time, Telford, Rennie and Brindley and others is admirably described in Smile's Lives of the Engineers in five volumes, which should be in the library of every Civil Engineer.

GARABIT BRIDGE.

The engineer was M. Gustav Eiffel. The structure crosses the valley of La Truyere at Garabit and is composed of a metallic viaduct of 1471′ length abutting on each end against masonry approach viaducts. The rail is at an elevation of about 400′ above the lowest point of the valley. The metallic portion of the viaduct is composed of a straight latticed girder, or system of girders, supported at each end on masonry abutments which form part of the masonry viaduct. The girder is further supported over each slope of the valley by metallic towers resting on blocks of masonry and over the deepest part of the gulch by bents resting on a large metallic arch of 541′ span.

The lattice girder consists practically of three continuous girders, the portion over the arch comprising one part and from the ends of the arch to the masonry approach viaducts the others. The girders are 17′ deep and the trusses are spaced 16½′ apart between centers.

The floor beams have five lines of stringers resting upon them, on which the corrugated floor is placed. This floor is strong enough to support the weight of an engine in case of derailment. The supports or bents under the spans are hinged, some being fixed and some resting upon cast iron rollers. The hinged supports have the advantage of causing the resultant to pass through the axis of support, which is a condition necessary in the case of very high towers.

The structure was figured for a live load of 3219 lbs. per lineal foot of track. The height of the lowest bent is 199.23′. The batter of the posts in the bents varies, being generally about 1″ per foot.

One item not usually found in American structures is a metallic stairway in the center line of the tower running its full height. This is built to facilitate the inspection of the structure.

The wind pressure used in calculating the strains was: first, a full live load and 30 lbs. per square foot; second, no live load and 55 lbs. per square foot.

THE CENTRAL ARCH.—The chord of the central arch is 541′ long. The rise of the intrados is 170′ 1¾″. It may be said to be composed of two large bents symmetrical with regard to a vertical plane passing through the center line of the track. but situated in two planes inclined towards each other.

The bents are 65′ 7/16″ apart at the bottom and 20′ 5/16″ at the key measured on the intrados. This arrangement makes the arch very stable against wind pressure. The two inclined bents are in the shape of a crescent, the middle fiber being a parabola. They are very high at the key but terminate in a point at each base. These points are hinged, thus forcing the resultant pressure to pass constantly through that point. This shape of arch has the advantage of giving it sufficient rigidity to resist the deflection due to uneven distribution of rolling load.

Each bent is composed of a top and bottom chord in the shape of box girders; the bottom one having the cover plate on the lower side. The open sides of these chords are latticed with angles. The vertical and inclined struts joining these chords are built of four angles latticed. The two bents are tied together by horizontal cross struts. The bracing is

completed by a very strong diagonal bracing in the intrados and extrados plane, the members being built of four angles latticed on all sides.

The foundations are on rock almost at the surface of the ground. The estimated cost of the structure is as follows:

For masonry, including the approach viaducts, $142,857.14; for superstructure (the metallic part) $447,619.05. The total cost, $590,476.19.

The price per running foot of the whole viaduct is $324.81; price per running foot of the metallic part $331.09.

SAULT CANAL.

The Sault canal and locks were built to carry commerce around St. Mary's Falls. The old canal and locks were built from 1853 to 1855. The locks, two in number, are each 70 feet wide, 350 feet long and have 11½ feet of water over mitre sills. They have a lift of 9 feet each. Total cost of canal and locks was $999,802.46.

The work of enlarging the canal and rebuilding the locks was commenced in October, 1870, and finished September 1, 1881. The total length of the canal is about 1⅓ miles (7,000 feet); the least width, 108 feet; depth, 16 feet. General height of canal pier revetment work is 4 feet above mean water surface. The new lock chamber is 515 feet long, 80 feet wide narrowed to 60 feet at the gates; depth 39½ feet with 17 feet of water over mitre sills. The capacity is 1,500,000 cubic feet.

The cut stone came from Marblehead, Ohio, and Kelly's Island. Backing stone from Drummond's Island and St. Mary's River. Face stone, mitre and breast walls and portions of wall adjacent to springs of water were laid in English Portland cement; the remainder of the work in Louisville cement. 34207 cubic yards of masonry were used, 35,000 barrels of cement being used in this masonry, every barrel of which was tested before use.

Mitre sills are oak timbers 12″x18″ fastened to the bed rock by bolts 10 feet long.

There are four gates, upper and lower lock gates and upper and lower guard gates. Weight of one lift of upper lock gate is 40 tons; the weight of one lift of lower lock gate is 76 tons. Both lifts of the upper guard gate are provided with valves with which to fill the lock after it has been pumped out. The lock can be filled through the above valves in about one hour. The guard gates are only used in case the lock gates are disabled or repairs are being made to the lock. Water is let into the lock from culverts under the floor. Each culvert is 8 feet clear, the water passing into the lock chamber through 58 apertures in the lock floor.

MACHINERY FOR OPERATING GATES AND VALVES. Power is obtained from two 30-inch turbines geared to a main shaft, water being brought to them through a supply pipe from above the lock.

Two accumulator pumps are used both of which can be run by one turbine at ¼ gate. The accumulator is loaded so as to give a pressure of about 120 lbs. per square inch.

The movable dam is designed to check the flow of water so that upper guard gates can be closed in case the lock gates are accidentally carried away. The dam consists of an ordinary swing bridge, one end of which

can be swung across the canal. A series of wickets is suspended side by side from a horizontal truss beneath the bridge. The total cost of improving the canal and the new locks was $2,150,000.

MANCHESTER SHIP CANAL.

The first consulting engineer was appointed (to look into the project and report) in the summer of 1882. It was only in August, 1885, after making three trials, that the sanction of Parliament was obtained for building the canal. Before a single sod was turned in the great work $1,-750,000 was spent in forwarding and contesting the canal project. In July, 1886, the contract for building the entire canal was let to Mr. Thomas Walker for $28,750,000. The allowed time for finishing the work was four years, with a large bonus for whatever time was gained in finishing.

The canal extends from Estham Locks on the south bank of the Estuary of the Mersey River to Manchester, having a total length of a little over 35 miles. The minimum width on the bottom is to be 120 feet. The depth throughout is to be 26 feet. This is a very large cross section when compared with existing canals, which are as follows:

Ghent canal 55 6″ wide on bottom, 21′ 2″ deep.

Suez canal 72′ wide on bottom, 26′ deep.

Amsterdam 88′ 7″ wide on bottom, 23′ deep.

Many minor streams are to be siphoned across the canal. The Mersey river has to be crossed six or more times. The Bridgewater canal has to be carried across the Ship canal by a swing bridge, no water being wasted in swinging. At this point also a hydraulic lift is to be built to lower barges and boats from the Bridgewater canal to the Ship canal, thence across it and up on the other side to the former level.

Quite satisfactory progress has been made on the entire work up to a recent date, when Mr. Walker very suddenly died.

Mr. E. Leader Williams is the Chief Engineer of this work and has been one of its principal promoters from the beginning.

As originally designed the canal was to extend several miles into the Mersey, and it was upon the effect of this extension that Mr. James B. Eads gave an opinion which was conclusive to Parliament that the works built as designed would lead to the deterioration of the channel over the bar at Liverpool. His argument on this subject with the illustrations drawn from maps and notes, some of which were a century old, is one of the best engineering papers extant, and was so conclusive to the minds of the committee that the plan was thrown out immediately. It was for this on which he spent about three weeks' time, he received probably the largest professional fee ever received by an American Engineer, at least, for an equal time spent on any subject, namely, nearly $17,000.

PANAMA CANAL LOCKS.

They were designed by Mr. Eiffel and were to be eight locks, four on the Atlantic and four on the Pacific side of the Isthmus.

Four locks, two of 8 meters (26¼′) and two of 11 meters (36.9′) lift will reach an elevation of 38 meters (124.67′) from Colon on the Atlantic side. Four other locks, three of 11 meters (36.09′) and one of 8 meters

(26 1-7′) will reach an altitude of 41 meters (134½′) measured from the Pacific ocean at Panama. The Eiffel locks 18×180 meters (59′ × 590½′) are about as follows:

The gate is really a large caisson which rolls in and out on tracks on a swing bridge, much like a big barn door hung on rollers and tracking overhead and underneath. The lower part of gate is arranged somewhat like the working chamber of pneumatic caisson. The caisson is suspended on rods fixed to wheeled trucks rolling on tracks as noted above.

The general dimensions of a lock of 11 meters are as follows:

Down stream gate, height 21 meters (69.88′), width 4 meters (13.12′), length 21.6 meters (70.85′). Up-stream gate, height 10 meters (32.8′), width 3 meters (9.84′) length 21.6 meters (70.85′). For an eight meter lock the height alone varies. other dimensions remaining about the same.

The free section of canal left by the opening of a gate is 18.6 meters (61′) at bottom and 20.6 meters (67½′) at the top or surface level. The locks are so located that they will be excavated in solid rock with very light masonry supports where the rock is shattered. The side walls are made of iron caissons having cast iron bracing, the interior being filled with beton. The dimensions of these side caissons vary with the size of the locks. For a lock of 11 meters lift they would be 5½ meters (18′); 24.25 meters (79½′) in height, 30 meters (98.4′) in length.

The caisson gates and swing bridges will be operated by chains running over guide rollers and worked by hydraulic power derived from turbine water wheels. The lock holds about 14,120,000 cubic feet of water and it is intended to fill it in fifteen minutes. Two cast iron mains about 9′ in diameter are to be laid under the entire length of the lock. They will be pierced at intervals of about 6½′ by holes 1.3′ in diameter. These pipes are deflected towards the side walls of lock entrance. Inside these walls they ascend to a height of 32 feet above the platform level, where they terminate in a sluice-way for valves opening into the canal. The estimated quantity of wrought iron needed in these gates will be 15 tons and cast iron 20,000 tons.

Mr. Eiffel designed, and, it is believed, took a contract for the construction of these locks and their gates. It may be of little interest at this juncture of Panama Canal affairs to describe these locks, but it is given for the purpose of showing the ingenuity and extent of the locks, and of the works connected with them. The contemplation of this whole subject of the Panama Canal brings anything but pleasure, but it is a satisfaction (though a poor one) to state that very few American engineers who had given the subject close attention, believed that the original sea level canal, on which several hundred million dollars was spent, was practicable, and it is to their credit that they publicly protested against such a wasteful expenditure of money, when there could possibly be nothing but failure in the result. It is extremely doubtful if the lock plan is feasible in operation, at least, on account of the scarcity of water at times, and it is doubtful whether the works are carried forward any further. The entire enterprise is in the hands of a liquidator appointed by the French Government, who has sent a commission of French engineers to Panama,

who are due there at about this time, and whose duty it will be to make a general survey of the Isthmus, the condition of affairs and the state of the work, and report to Mr. Brunet, the Liquidator, what in their opinion is the best method (if any there be which can be successful) of completing the work and opening it to commerce. It has been asserted by those who are competent judges, that the only successful method of overcoming this great barrier to commerce at the Isthmus of Panama, is by a ship railway connecting the dredgible portions on either side.

ST. LOUIS BRIDGE—JAS. B. EADS, ENGINEER.

The first work on the bridge was in August, 1867. The bridge was formally opened in July, 1874. The river at the bridge site is narrowed to about 1,600′ in width at low and ordinary stages of water by a dike built along the Illinois shore. At high water the width is about 2,200′. The bottom is changeable being covered with a heavy bed of sand and gravel (the sand being very light) which is liable to wash out almost if not quite to bed rock during any heavy freshet, records having shown that 50′ or more in depth had been cut out during one freshet.

The bridge has three spans formed of rolled steel ribbed arches, each span being made up of four double ribs of steel so cut as to form one heavy arch. The spans are 502′, 520′ and 502′ in the clear between the piers. The rise of the center arch is 47½′ and of side arches 46′. The total length between abutments is 1,627′. The clear headroom above the water at center of the arch is about 53′. The range of the river between high and low water is a little over 41′.

The piers are founded on the bed rock, the final locations below low water being as follows: East abutment 94′, east pier 85′. west pier 56′ 10″, west abutment 13′. At the time this bridge was built engineers did not understand how to protect workmen from bad effects of compressed air as well as they do now and in sinking the piers 600 men were attacked by sickness; 14 deaths occurred and two victims were crippled out of the 600. The maximum air pressure was about 50 pounds above the normal. The greatest depth at which pressure was carried was about 110 feet.

The superstructure was erected without falseworks. Temporary towers some 50′ high were raised on the tops of the piers and cables run from these to the semi-arches. On the piers the work was built out from both sides at the same time keeping the parts balanced, while at the abutments the switch cables were run over towers and anchored securely on the shore. The maximum strain in these main cables was 170 tons.

The size of the piers is as follows: East abutment at base 83x70½′, at top 64′ 3½″x47′ 6″. The east pier 82′x60′ at base and 63′x24′ at top. The west pier 82′x48′ at base and 63′x24′ at top. In these main piers and abutments some 68,727 cubic yards of masonry were used in all, being faced with granite. The total weight of metal in the three main spans was some 5,547 tons, the weight of railway track, etc. was estimated at 215 tons, the estimated weight of lumber in the bridge 806 tons, total weight of the three spans 6,568 tons or 4.3 tons per foot. The total cost of the bridge was $6,536,729.99. This was somewhat in excess of the engineer's estimate due to two causes; first, enlargment of plans made during con-

struction; and, second, unexpected difficulties in sinking the piers. This was largely due to its being in nearly every respect a pioneer work. No such depths had ever before been attempted; the length of spans were uuusual and the character of the spans was equally unusual. The bridge has not only two tracks for railroads but above them a wagon bridge about 50′ wide. This added largely to the cost of the approaches on each side of the river. It is considered rightfully one of the most beautiful engineering structures in the world.

THE NEW YORK AND BROOKLYN BRIDGE.

The engineers were John A. Roebling and his son Washington Roebling.

This bridge was formally opened in 1884. The first actual work on the structure was done in October, 1869. About five years were consumed in building the piers and towers.

The length of the bridge including anchorages is 3,700′. The height of the anchorages 85′; the weight of each anchorage is 60,000 tons; the length of each land span is 930′, the length of the middle span 1,600′, the size of the towers at high water mark is 140×59′, the height of the towers from high water mark is 272′, the height of towers from the deepest foundation to the top is 350′, the width of grade is 85′. Head room above high water 135′, number of cables four, the length of one cable 3,580′, the finished diameter of cable 15½″, the number of railroad tracks two, the grade of the bridge 3¼ per cent, allowable speed for trains is 10 miles per hour, total cost from anchorage to anchorage exclusive of land damages $5,600,000.

The distance from the centre of the Brooklyn tower to the face of anchorage is 930′. The anchorage pier on the Brooklyn side is 132′ long by 119′ 4″ extreme width, 85′ 6″ back of face and 109′ 4″ from thence to the end. This anchorage pier is founded on a timber platform some 3′ thick and thoroughly bolted together. All air spaces in the platform are filled with concrete; it is also surrounded by concrete. The anchorages contain about 28,800 cubic yards of masonry for the New York side and 27,113 cubic yards for the Brooklyn side.

BROOKLYN TOWER. The bottom of the foundation is at a depth of 44′ 6″ below mean high tide. The bottom of the masonry is at a depth of 20′ below mean high tide. Depth of the water along the front of the tower from 12′ to 16′. The height of roadway above high tide is 198′ high.

NEW YORK TOWER. The bottom of foundation is 78′ below mean high tide. The bottom of masonry is at a depth of 46′ 6″ below mean high tide. The depth of water in front of the tower is 34 feet.

The areas at bottom of caissons are: Brooklyn tower 102′×168′ equals 17,136 sq. ft. New York tower 102′×172′ equals 17,544 sq. ft.

The area at the bottom of masonry is, for Brooklyn tower 151′×49′ equals 8,542 sq. ft. New York 77′×157′ equals 1,115 sq. ft.

The Brooklyn tower has 25,394 cubic yards of masonry below the roadway and 6,033 cubic yards from the roadway to the swinging line of arches, and 6,787 cubic yards in remainder of the tower. In the tower

and caissons there are about 38.314 cubic yards of masonry, 56,669 yards of concrete and 5,253 yards of timber and iron.

The New York tower has 46,945 cubic yards of masonry while timber and concrete are about one-third more than in Brooklyn tower. The total weight of the Brooklyn tower is 93,100 tons; the pressure at bottom of the foundation is 5½ tons per sq. ft.; at base of central shaft above roadway about 26 tons per sq. ft. The arches over roadway are 33′ 9″ span and their points 114 1-3′ above the road bed. The beds of all stone were rough axed so as to allow the use of ½″ bed joints. The excavation in the caissons cost for labor alone about $5.25 per cubic yard and this with air compressors, lights and other expenses made the total cost, not including any material, about $10.50 per cubic yard. The foundations for the arches were carried down to a solid bottom. In general this bottom was found at a little over three feet above high tide though in many places they dug from 10′ to 12′ below tide level. The maximum pressure on the bottom under these foundations is about 5 tons per sq. ft.

SIOUX CITY BRIDGE.

This bridge was built over the Missouri River at Sioux City, Iowa, in 1887 and '88. It is owned by the Chicago & Northwestern Ry. Co. The Chief Engineers of the work were Messrs. Morison & Corthell, members of the Society, and Mr. E. Gerber was Resident Engineer.

The bridge consists of four 400′ spans and one 61½′ approach girder all resting on first-class masonry supports. The main piers were built on pneumatic caissons which rest on the sandy alluvium of the Missouri River, no rock being found at a convenient depth. The pressure on the foundation material is about three tons per square foot with, of course, a large frictional resistance on the sides of the caissons and cribs. All of the foundations are about 86′ below low water, the deepest pneumatic work was done at 94′ below low water. The range of the river between high and low water is about 17′, the superstructure for the main bridge weighs 4,485,800 lbs.; one 400′ span weighs 1,114,300 lbs. There are in the piers and abutments 6,990 cubic yards of masonry and 3,000 yards of it being granite. It is a single track structure built entirely of steel except a few castings. The views which illustrate this bridge construction are selected from a large number which were taken during the progress of the work and are intended to illustrate the method and progress of the work from the time when the work was commenced until it was entirely completed and tested. The views will show the methods of building the caissons, of excavating the material, the building of masonry, and the erecting of the superstructure. Many of these stages of the work shown progressively and as an object lesson will be of interest to all.

The Union Bridge Company of New York manufactured the superstructure.

CAIRO BRIDGE.

This bridge has been recently built by the Illinois Central Railroad Company, and is now open for traffic. It spans the Ohio river at the

City of Cairo, Ill. It is one of the longest structures in the world. It lacks but about 160′ of being the longest, that being the new Tay bridge. On account of the low banks on either side of the river at Cairo, the great rise of the water being 52.17′ between low and high water, and the height required for steamboats 53′, the structure is elevated above the country on either side, so that the entire length of the permanent structure is 10,560′ being made up of the following spans:

Two 518½′ spans,
Seven 400′ spans,
Three 249′ spans,
Thirty-eight 150′ spans,
Two 106¼′ spans.

Total amount of steel in the main bridge was 13,411,656 pounds; in the Kentucky approach there are 4,355,149 pounds; in the Illinois approach 3,496,278 pounds. There are 32,266 cubic yards of masonry in the piers. There are 17 cylinder piers in the Illinois approach and 21 in the Kentucky approach. One 518½′ span was erected in 44 working hours, and one 400′ span in 23 hours. This is believed to be as rapid work as has ever been done in the erection of large spans.

The foundations of the piers were generally placed 75′ below low water and rested in the alluvial formation of the Ohio river, being in many cases nearly pure sand, in others sand and gravel. Some sand rock and some clay were encountered in sinking the foundations. The entire work in the river was done by sinking pneumatic caissons. The chief engineers were Messrs. Morison & Corthell, the resident engineer, Mr. Alfred Noble. The Union Bridge Company of New York had the entire contract for the foundations, piers and superstructure of the main bridge and permanent approaches.

OHIO RIVER BRIDGE AT CINCINNATI.

The bridge consists of two spans 490′, one single span 550′ and about 1,500 lineal feet of approach in Covington and 3,000 lineal feet in Cincinnati. The 490′ spans are 484′ 6″ between centers of end pins. The 550′ span is 542′ 6″ between centers of end pins. The trusses of the main span are of steel, the remaining material of iron. The long span is 84′ deep at center and 60′ at end by 30′ in width center to center of trusses and weighs 4,000,000 lbs. The two side spans are 75′ center depth and 50′ end depth; 30′ in width center of trusses and weighs 3,330,000 lbs. each. The structure carries a double track railway and two roadways and sidewalks and the entire weight is about 24,000,000 lbs.

The erection of the iron work of the river spans was commenced July 6th, 1888, and though all the false work, the traveler and most of the floor of the long span was washed out by the flood of August 26th, and much delay was caused in getting falsework in for the Cincinnati shore span, yet the first train crossed the structure December 25th, 1888. The last span was swung in 16 days from the placing of the first iron. In this erection single pieces weighing 37,000 lbs. were handled.

The Phœnixville Bridge Co. built this structure. The largest span of this bridge is probably the heaviest independent truss span in the world.

THAMES RIVER BRIDGE.

New London, Conn., on line of N. Y. P. & B. railway.

This structure is principally noted for having the longest double track draw span in the world—503′ between centers of end piers. The maximum depth of water at the crossing is some 57′. The distance from low water to the bottom chord of bridge is 38′. The piers are founded on piles driven at deepest point through more than seventy feet of mud and clay into a gravel bed. The total length of bridge between centers of abutments is 1,423′, made up of two spans 310′ each, two spans 150′ each and a draw span of 503′. The spans are arranged symmetrically about the pivot pier draw. The principal dimensions of which are as follows:

The width center to center of trusses 28′ 4″, end height between centers of chord 25′, center height between centers of chords 71′; the distance from base of rail to masonry on pivot pier is 19′ 1″. The diameter of turntable is 32 feet and is rim-bearing. There are 58 cast steel wheels 20 inches in diameter and 10″ face and weighing 800 lbs. each. The load is distributed to the drum from eight equi-distant points. The weight to be moved in swinging bridge is about 1,300 tons. The draw span is equipped with a double oscillating engine 10″×7″ stroke. The average speed is 175 revolutions per minute. The end arrangement runs out in 15 seconds and the draw can be opened in 2½ minutes.

Mr. Alfred Boller, Civil Engineer of New York City, was the Chief Engineer and the Union Bridge Company had the contract for the entire structure.

HAWKESBURY BRIDGE.

This is specially remarkable for the great depth of foundations. Total length of the structure between abutments 2896′ divided into seven spans, the end ones being 408′ between outer face of abutments and center of first regular pier, the remainder of the spans being 416′ between centers of piers. All spans 410½′ center to center of end pins, 58′ high between centers of girders and 28′ wide between centers of trusses. Clear head room above high water is 40′.

The superstructure is of the ordinary double inter-section, quadrangular, pin-connected type. The spans were erected on pontoons and floated into position between the piers, being located over the piers at high tide when span floated clear; as the tide fell the span rested upon the bridge seats.

The caissons for the piers were elliptical and 24×62′ at the cutting edge. They were settled through mud and sand strata into a bed of hard gravel which is about 126′ below the river bed, 185′ below high water and 227′ below the track on the bridge. The caissons were sunk by dredging through three tubes eight feet in diameter, terminating in bell-mouthed expansions which met at the cutting edge. The filling of the caissons to low water was made of concrete; above low water cut stone masonry was used. The piers above the concrete portion consist of two circular columns 14′ in diameter and 28′ apart, centers connected by a wall six feet thick.

The caissons were sunk as follows:

Pier.	Low Water to River Bed.	Depth Below River Bed.		Total Depth Below Low Water.		Total Height of Pier.	
	Feet.	Ft.	In.	Ft.	In.	Ft.	In.
Pier I	38	55	8	93	8	135	8
Pier II	40	108	1	148	1	190	1
Pier III........	43	96		139		181	
Pier IV........	21	118	6	139	6	181	6
Pier V	19½	117	5	136	11	178	11
Pier VI........	47	108		155		197	

Pier VI in sinking 80′ got out of position moving toward the shore and end-wise. A load of rock was dumped in on the shore side, the caisson forming a fulcrum. Heavy cables extending to shore were used to draw the top of the caisson in, that is, towards shore, thus throwing the stone out. These appliances succeeded in drawing the caisson into its proper position before reaching its final resting place. The total cost of bridge proper as per contract was $1,654,800. The time allowed for building was two and one-half years. The Union Bridge Company had the contract for the entire structure.

FIRTH OF FORTH BRIDGE.

Designed and built by Messrs. Fowler and Baker, Chief Engineers.

At the point where it crosses the Firth the water is 200′ deep in places, making use of staging impossible. Violent storms are also of frequent occurrence.

The total length of structure is about 1½ miles. The main bridge is made up of three immense cantilever spans connected by short suspended spans. The approaches are made of ordinary lattice girder spans 168′ in length. There are three main piers, the Fife, Inch Garvie and Queensferry pier. Each main pier is made up of four smaller piers or columns of granite faced masonry. The height of these small piers or columns is 36′, diameter 55′ at the bottom and 49′ at the top. Each of these piers contains 48 steel bolts 2½″ in diameter by 24′ long for anchoring the structure.

Part of the foundations below low water was put in by use of open dams, and part of them by the pneumatic process. Two of the Inch Garvie piers were located where there was a depth of 72′ at high water and where the bottom was rough and sloping. The sloping bottom was leveled up with bags of sand to give caisson an even support. The rock was then taken out and caisson lowered until it reached a full level bearing on rock.

At Queensferry all four piers were founded upon caissons sunk to bed rock or into a hard boulder clay bed over-lying the rock. The greatest depth below high water was 89′. The time required for placing all the caissons was about two years. The greatest air pressure used was about 35 pounds. In all the work of sinking caissons there were no deaths of workmen attributable to working under heavy air pressure.

The superstructure of main bridge consists of two cantilever spans 1,-

710′ in length each, and two spans 675′ each (being the shoreward arms of cantilevers).

The approaches are made up of spans 168′ each. The middle or suspended spans are 350′ each in length, included in the 1,710′ above noted. These suspended spans are 50′ deep at centre and 41′ at the ends. Their weight is about 896 tons each. One end is fixed to the cantilever arm and the other end is movable for expansion. The spans connecting the four columns of the main piers, which may properly be called towers, are, two of them, about 150′ each, the third being some 265′.

The distance from water surface to tops of main towers is 360′. The clear head-room under the center of bridge is 152′ at high water. The tower columns are 120′ apart at base and 35′ apart at the top. One of the 1,710′ spans weigh about 17,900 tons. The heaviest rolling loads known only make about 900 tons or, say 5 per cent. With assumed wind pressure of 56 pounds per sq. ft., the estimated lateral pressure on each 1,710′ span is 2,240 tons, or, 2½ times as much as the rolling load.

The main compression members are cylindrical tubes as that form gives the greatest strength with the least weight. The largest tubes are 12′ in diameter, the shell being about 1¼″ to 1⅞″ thick. Each cantilever tube is subject to a pressure of 2,555 tons from dead load, 1,145 tons from live load, and 3,270 tons from wind. The tension members are similar to our ordinary heavy latticed structures, being composed of plate and angle sections, and being formed into trusses having top and bottom chords which are about twelve feet apart in the maximum.

The lower parts of bed plates on the piers are made up of several steel plates riveted together, the weight of this lower plate is nearly 45 tons, the upper part of bed plate is left free to slide over the lower or rigid portion. The former portion forms part of the base of the skew-back. The plates of cylindrical columns are bent into shape while hot by a bending press, the rams being capable of exerting a pressure of 1,780 tons. The plates had an extra squeeze given when nearly cold to prevent their twisting.

The erection of the cantilever spans was commenced at the piers and worked both ways. All the rivets in the tube are machine driven, the machines being hydraulic and weighing nearly 18 tons each. At times 800 good rivets were driven per day of ten hours at a height of 300′ above high water. The estimated number of rivet holes in the large cyrindrical compression member is 5,000,000.

The approach girders were erected on piers when only a little distance above the ground. They were then raised by hydraulic jacks, several spans at a time, and stone work was built up underneath in steps of about 3½′.

ST. LOUIS MERCHANTS' BRIDGE.

This bridge is being built by the St. Louis Merchants' Bridge Company for the purpose of affording a competing line across the Mississippi river at St. Louis. It is located about 2½ miles above the Eads' bridge and connections are made with the various railroads on each side of the river. The river is spanned by three independent trusses of steel, each truss being about 520′ long.

The bridge is a double track structure 52′ above high water in its cen-

ter and about 50′ at the ends of the bridge. The total length of the permanent steel and masonry bridge is 2,420′. The river at the bridge site is reduced to a width of about 1,600′ by means of a permanent dike on the bridge approach and by a brush dike 1,000″ above it.

It was not necessary at this bridge to go to so great a depth as at the old bridge to reach the bed rock which is nearly level at this point and is at an average depth of 46′ below low water. The bridge is built on pneumatic caissons 70′ long and 26′ wide for the shore piers, 70′ long and 28′ wide for the two river piers. Missouri granite is used for the masonry to the high water line and above that Bedford limestone is used. At either end of the main bridge there was about 425′ of deck spans with viaducts and spans over streets and the railroads. All of the structure is of steel.

The consulting engineer of the bridge is Mr. Geo. S. Morison, member of the Society, who has designed the superstructure, the chief engineer is Mr. E. L. Corthell, member of the Society, and the resident engineer in entire charge of the work is Mr. H. W. Parkhurst also member of the Society. The contractors for the entire main bridge and 425′ of the permanent approaches are the Union Bridge Company of New York. The superstructure of this bridge, as well as of the Cairo bridge and of several other large bridges of a similar character, has been erected by Baird Brothers who have been very successful in their work in every instance.

The St. Louis Merchants' Bridge has probably been built in the shortest time of any bridge over the lower Mississippi river and, perhaps, in the shortest time of any bridge ever built of its magnitude. It has practically been built within one year's time. The last of the main spans is erected.

MEMPHIS BRIDGE.

This bridge is now being constructed over the Mississippi River at Memphis, Tenn. The Chief Engineer of the bridge is Geo. S. Morison and the Resident Engineer Mr. Alfred Noble. The bridge will be principally remarkable for the length of its three main spans which are, beginning on the Memphis side, respectively, 790, and two 621 ft.

The continuous superstructure will consist of a central span (resting on piers II and III) 621 feet 0½ inches long, from each end of which will project a cantilever arm, 169 feet 4½ inches long; of an anchorage span (from the Anchorage Pier on the Tennessee shore to Pier I), 225 feet 10 inches long, from which will project a cantilever arm precisely like those projecting from the central span; of two intermediate spans 451 feet 8 inches long, (one of which will be suspended from the cantilever arms projecting from Piers I and II, and the other will be suspended at the east end from the cantilever arm projecting from Pier III and will rest at the west end on Pier IV), the entire continuous superstructure being 2,258 feet 4 inches long, divided into one span of 225 feet 10 inches, one of 790 feet 5 inches, and two of 621 feet, 0½ inch.

This continuous superstructure will be rigidly fastened to Piers I, III, and IV, but will rest on expansion rollers on Pier II. Slip joints will be provided for expansion at the suspended ends of the independent spans.

The trusses will be placed 30 feet between centers, and will be divided into panels 28 feet 2¾ inches long, the right being reserved to shorten the panels by an amount not exceeding one-half inch at any time before the work is actually manufactured.

The Deck Span at the west end will be 338 feet 9 inches long from the center of Pier IV to the center of the pin on Pier V, divided into twelve panels of 28 feet 2¾ inches each, the trusses being placed 22 feet between centers. The east end of the span will be carried in niches on the west side of Pier IV; the west end will have roller bearings over the center of Pier V. This span will include a vertical bent which will carry the west end of the west pair of stringers.

The estimated approximate weight of the continuous superstructure is 13,000,000 pounds; that of the deck span 1,000,000 pounds, making the total estimated weight of the superstructure of the bridge proper 14,000,000 pounds.

The caisson for pier I, which is located between the high and low water lines on the Tennessee side of the river is to be 308′×70′ and 53′ high, the plan being similar to those of the channel piers at Cairo. It is to be sunk 45′ below low water. Caisson for pier II is 47′×92′ and is 60′ high, to be sunk 94′ below low water. Caisson for pier III is 47′×92′ and 40′ high, to be sunk 80′ below low water. For pier IV it is 26′×60′ and 50′ high, and is to be sunk 60′ below low water. Caisson for pier V will be 22′×40′ and probably 80′ high, and will be sunk 55′ below low water. The character of the foundation in which these piers will rest is: first, a light clay reaching to a dark blue hard clay which no doubt will be of ample consistency to bear the weight of the structure.

EIFFEL TOWER.

As preliminary to the brief description of the Eiffel Tower, the following extract from *London Engineering* will show what a complete failure, architecturally, at any rate, was predicted and what a complete success was realized by the design and construction of this remarkable monument to the genius of a civil engineer:

"On the 5th of November, 1886, the Finance Committees of the Paris Exhibition voted a credit of 1,500,000 francs as a subsidy for the unique and monumental work M. Gustav Eiffel had undertaken to construct, and which was to be one of the great original features of the Exhibition. The idea of erecting a tower 1,000 feet in height was received with a very general feeling of distrust and even of dismay; not that any one doubted the capability of the bold and successful engineer to complete the work to which he had pledged himself, but the misgivings were very general as to the effect such a novel construction would have upon the architectural features of the Exhibition, and the wide-spread cry of influential voices went up from Paris as a protest against the engineering outrage that was to be inflicted upon the French metropolis. It is rather curious, now that the tower is completed, and the great consensus of public opinion is loud in its approval, to recall the remonstrance addressed to M. Alphand, the Director General of the works, against the proposed column. 'We wish authors, painters, sculptors, architects, enthusiastic lovers of beauty which

has hitherto been respected in Paris, to protest with all our energy, and with all the indignation with which we are capable, in the name of art and of French history now menaced, against the erection in the heart of our capital of the useless and monstrous Eiffel Tower, which public satire, often full of good sense and a spirit of justice, has already christened the Tower of Babel.'"

"Is the city of Paris to permit itself to be deformed by monstrosities, by the mercantile dreams of a maker of machinery; to be disfigured for ever and be dishonored? For the Eiffel Tower, which even the United States would not countenance, is surely going to dishonor Paris. Every one feels it, every one says so, every one is plunged into the deepest grief about it, and our voice is only a very feeble echo of universal opinion, properly alarmed.

"To this vehement protest was attached the names of many of the best known men of France: Meissonier, Gounod, Garnier, Sardou, Gerome, Bonnat, Bouguereau, Dumas, Coppee, etc. But these well-meant. ill-judged remonstrances were not heard, and to-day the Eiffel Tower stands completed, the marvel of the Exhibition and the glory of the constructor. The noble monuments of Paris apparently thrill as much as they did before with the genius of the centuries, and the grand proportions of the Arc de l'Etoile do not seem to have suffered because a great French engineer has achieved a triumph of construction."

Active work on the foundations was commenced in Jan., 1887, after a very careful investigation of the ground had been made in ascertaining the nature of the formation upon which the structure was to rest. A large number of borings were taken on the Champ de Mars, showing that there was a bed of hard compact clay about 52′ in thickness resting upon the chalk formation, enabling it to carry with safety from 3 to 4 tons per sq. ft.

There were four independent foundations each standing at one angle of a square, about 330′ on a side. The gravel on one side was met at a depth of 23′ below the surface, and the thickness of it was 18′. The piers are built upon a bed of cement concrete 7′ in thickness. The other two piers nearest the Seine were in different material: the bed of sand and gravel was 40′ below the surface, that is, 16′ below the mean level of the Seine, and was over-laid by soft deposits. Work was performed by means of caissons with compressed air to a depth of about 52′. The caissons were of iron 49′ long and 20′ wide. On this concrete were built masonry piers. Each one was built with one face vertical towards the centre of the tower, the outer corresponding face being inclined at the same angle as the column of the tower. The two other faces are vertical and parallel. The top of the pier is at right angles to the back face and therefore normal to the springing of the column. The total load which each of the piers on the two foundations nearest the Champs de Mars have to carry is 1,970 tons, and the load on the masonry is equal to about 3 tons to the sq. ft.

In reference to the superstructure the leading principle followed was that adopted by M. Eiffel in all his elevated structures, namely, to give to the angles of the tower such a curve that it should be capable of resisting the transverse effects of wind pressures without necessitating the connec-

tion of the members forming these angles by diagonal bracing. The Eiffel Tower therefore consists essentially of a pyramid composed of four great curved columns independent of each other and connected together only by belts of girders at the different stories until the columns unite towards the top of the tower where they are connected by ordinary bracing. Iron and not steel was used in the construction throughout.

The tower terminates at a height of 896′ above the ground with a platform about 53′ square, the width of the column at this level is 33′ the gallery being carried by brackets. Above the platform rises the campanile. In the lower part of this is established a spacious and very complete library, closed to the public, and intended for the prosecution of scientific research and observation. Four latticed arched girders rise diagonally from each corner of the lower part of the campanile and unite at a height of about 54′ above the platform; by means of a spiral staircase yet another gallery is reached about 19′ in diameter and surrounding the lantern which crowns the edifice and brings the height of the structure to 984′; above this rises the great lightning conductor. The area of the first story, which is mostly devoted to restaurants of various nationalities, is 38,000 square feet, the second floor has 15,000 square feet. Elevators of various kinds take one from one story to the other to the top of the tower. The complete success attending the construction and the erection of this tower and of the many appliances which belong to it makes it a marvel of engineering skill.

MISSISSIPPI JETTIES.

The greatest achievements of our profession are not always those which appeal to the eye. What we work for in our profession are results for the good of mankind. If we can combine with our bridges which cross the great river's lines of beauty so much the better, but there are certain works built for commerce and whose benefits to the human race are almost incalculable which to the eye have no lines of beauty, are rough and unhewn as it were, and yet are so substantial as to endure the greatest servitudes of the sea and all so well planned both in location, materials of which they are composed and in general design as to accomplish results which are very far reaching in their effects. This is the case of the Mississippi River Jetties. The beautiful bridge which spans the river at St. Louis is a monument to the genius of the engineer that conceived and built it, but the jetties built of willow brush and broken rock, covered with the muddy deposits of the Mississippi River, overgrown with rank grasses and by the drift logs which the currents bring from the uplands to the Gulf, is a greater monument to the genius of the same engineer. Those rough works have become the gateway of 'a continent; they have now for more than a decade stood boldly and successfully against the onslaught of the waves and the undermining of the currents; and it is a satisfaction to know that the work was conceived and executed by a Civil Engineer in the face of the most pronounced and decided predictions of utter failure. It is a satisfaction still more to state to-night that after the passage of ten years of time the channel which was carved through the obstructing bars by these works is deeper and wider and more

adequate than ever for the commerce which passes through it. It is now a common thing for heavily laden vessels drawing from 26 to 27½ feet to pass through the jetty channel without any detention. Formerly, before these works were commenced, there was a depth of water about 8 feet on the South Pass bar and commerce was continually striving to pass through an artificial ditch kept open by a dredging machine at the mouth of the Southwest Pass. It is not intended now to give a description even of these works. They are matters of history and every engineer knows more or less about them and how they were built. Rough mattresses of willows as a foundation, these covered with stone to hold them in place until a heavier concrete capping could be put upon them; one jetty extending 2½ miles from land into the Gulf, the other 1,000 feet from it and parallel to it. These main jetties were covered with concrete blocks some of which at that time were the heaviest that had ever been built in a seaway, the outer blocks weighing 181 tons. The main portion of this work has never been disturbed by the elements. One of the views thrown on the canvass will show the concrete wall which has within the last year been built on the original concrete blocks; another view will represent an inner jetty about 150 feet from the line of the main jetty, built for the purpose of causing the enclosed area to be filled by deposit from the river and the waves, and to prevent the washing of sand into the channel by the waves as they come over the main jetty in times of storm. The available width of navigation between the inner jetties is about 700 feet.

One of the most difficult undertakings connected with the entire work was the controlling of the channels and currents of the main river at the head of the Passes, 12 miles above the jetties. It was considered by Col. W. Milner Roberts that this was the most difficult engineering work in river hydraulics which the world has ever seen, far exceeding the difficulty met with at the mouth of the Pass; for at the latter points it was simply a question of guiding the currents out of the Pass into the Gulf; at the head of the Passes, however, the problem was how to maintain the currents into the small pass, carrying only about ten per cent. of the flow of the river, while the two wide passes on either side its main volume to the sea, and that too flowing over a river bed that was almost as movable as the water itself. Without going into a description of these works, we will simply say that the river in its entire volume and its great width of a mile and three-quarters, 30 feet deep, with a strong current, was bridled by cheap, rough mattresses laid as sills upon the beds of the great passes and guiding and holding the volume of water into South Pass as required, deepening the bar at its head from 15 to 40′.

Perhaps the greatest honor that has ever been conferred upon an American engineer was bestowed upon the author and constructor of these great works. The Society of Arts of Great Britain presented to Mr. James B. Eads the first of the Albert Medals ever given to an American citizen for his great works in opening and improving the water communications of North America.

CHIGNECTO MARINE RAILWAY.

For many years an indefatigable Civil Engineer has been at work

promoting a marine railway project for connecting the waters of the Bay of Fundy with those of the St. Lawrence across the Isthmus of Chignecto, by which 600 miles of troublesome, dangerous and expensive navigation will be saved by taking vessels over land a distance of 17 miles. All of the coast-wise business coming out of the St. Lawrence river destined for New Brunswick, Maine, and ports farther south will take advantage of this shortened route when this work is completed. The line will be perfectly straight, the grades 10′ to the mile, the size of the hydraulic lifting docks will be 235×60′, the length of the hydraulic rams 40′, the width of the roadbed 40′, the gates 60′ wide at the sea level. The railway will consist of a double track road of four rails, the weight of rails being 110 lbs. per lineal yard, many of which are already rolled and on the grounds. The length and width of the largest carriage will be 210×40′ in three segments. The lifts will be capable of lifting vessels of from 2,000 to 2,500 tons displacement weight, and it is expected that it will require but 2½ hours time to pass from the Bay of Fundy to the opposite water—the Bau Verte.

According to the rates which have been determined upon a vessel of 1,000 tons register will pay $750 as its fare across the Isthmus. It will be cheaper to pay this sum than to make the 600 miles trip around Nova Scotia. The Canadian government in its desire to promote a passage across this Isthmus has guaranteed for 20 years the interest on an investment of $5,000,000.

When this railway is built (and it is now under active construction with the expectation of being put into operation within a year) the practicability and the commercial advantages of a ship railway will be demonstrated by a model of very large size; in fact, the success attending this primary work will no doubt lead in the near future to the building of similar works and on a larger scale in many parts of the world where the natural conditions are not favorable to canal construction or navigation, notably across the American Isthmus, across the Peninsula of Florida, between Georgian Bay and Lake Ontario, between Rock Island on the Mississippi to Hennepin on the Illinois river and at many other points where the natural conditions prevent the economical construction of waterways.

The Resident Engineer of the Chignecto Marine railway, and to whom the project is no doubt most largely indebted for its realization, is Mr. H. G. C. Ketchum, a Civil Engineer of New Brunswick. The Chief Engineers who are designing and building the mechanical appliances and have general charge of the work are Messrs. Fowler & Baker, the Chief Engineers of the Forth Bridge. The fact that such men as these have charge of this work is a surety of complete success.

TEHUANTEPEC SHIP RAILWAY.

The last conception and project of Mr. Eads of whom we have already spoken as the designer and builder of the bridge over the Mississippi river at St. Louis and of the Mississippi Jetties, was that of a ship railway across the American Isthmus at Tehuantepec in Mexico. It may be of interest to state that when after four years of constructive work at the mouth of the Mississippi and after seeing what the grand commercial result of these works would be, his thoughts naturally tended to how to give to this same

commerce an outlet into the Pacific Ocean. It was not a submerged bar easily moved by currents directed against it by well designed jetties, but the great backbone of a continent which stood in the pathway of commerce. He said to himself "if we cannot remove this obstruction let us surmount it," and immediately set at work designing, while at the mouth of the Mississippi river, a railway that would carry heavily laden ships across the Isthmus. That was in 1878, and from this time until his death in 1886, he was constantly at work, either here or in Europe, upon this great project. He had an unswerving faith in it and an entire confidence of complete success, and gave to this work all of that marvelous ingenuity of which he was possessed. Since his death his co-workers have not been idle, but have been at work perfecting the plans and endeavoring to secure that large financial aid which is necessary to carry out a project involving from 60 to 75 million dollars.

NEW ORLEANS BRIDGE.

It was not many years ago that it was thought impracticable to build a truss span 500′ in length and there was a vigorous discussion on that subject in reference to a proposed bridge at St. Louis. Since then many such spans have been built and they are now turned out as standard plans, as it were, and placed across many rivers. At Memphis when the navigation interests and the U. S. government demanded a span 770 feet clear length the engineer rose to the occasion and planned it and is now building it.

It is now proposed to bridge the Mississippi River at New Orleans below all of its tributaries and where its volume has carved a deep permanent channel in the alluvial lands of the Delta. The demands of navigation and of the government are still more severe here than they were at Memphis and nothing is permitted in the way of spans less than 800′ in the clear or less than 75′ in height for the steamboat navigation and 82′ for the great naval cruisers of the U. S. Government. The river is half a mile wide and it is boldly proposed to throw a bridge across this river with only two piers in the river bed making the three spans independent each 866 feet in length, a double track steel bridge with steel approaches. This bridge will connect the Texas & Pacific and the Southern Pacific R. R.'s on the west with four main lines on the east, and will permit these western roads to enter the city of New Orleans from the rear and to reach a union depot which it is proposed to build in the heart of the city in connection with a belt road connecting all of the railroads. The bridge in many respects will be exceptional. It will be founded in the alluvial bed of the Mississippi River where there is no bed rock and where the foundations must be broad enough to not have placed upon them more than 3 or 3½ tons per sq. ft. It is proposed to erect the spans on floating pontoons similar to those employed at the Hawkesbury bridge, New South Wales, where spans over 400 feet were floated quite a distance and put in position by this means. The plan of the bridge may, however, be modified radically by building a continuous girder on the same principle as that already described of the Britannia bridge and similar also to that proposed for a high bridge across the Detroit River where

the conditions as to width are very similar to those at New Orleans. The engineer of this bridge project is Mr. E. L. Corthell.

DETROIT RIVER BRIDGE.

In 1874 Mr. James F. Joy, then President of the Michigan Central R. R., during a contest with the river interests in reference to the bridge at Detroit, stated that the world would not forever stand still on the banks of the Detroit River. It has stood still about 15 years since that time but now the world is in a fair way to move across. The business since 1874 has very greatly increased between the East and the West and particularly at this point. The obstacle to the free, economical and uninterrupted navigation across this river is the severe winters accompanied by heavy ice which makes the crossing difficult and diverts during the winter from this route much of the travel that naturally belongs to it. Various plans for a bridge have been proposed but the interests of navigation are so important, that any kind of a bridge but a high bridge, high enough to allow the tallest mast to go under it and wide enough to not present any material obstruction to the monuments of commerce is absolutely necessary and is imperatively demanded by the vessel interests.

Mr. Gustav Lindenthal, a Civil Engineer of reputation and ability, has proposed and made the design for a bridge with only two piers in the river with a clear height of 135′ at the piers and at the middle of the bridge of 140′; the middle span is to be 1020′ in the clear, the side spans 700′, the towers nearly 300′ high, the approaches about 1½ miles long. The bridge will be a continuous girder resting on four piers, the height of the superstructure being uniformly 120 feet high, the entire length of the bridge. It is intended to erect the side spans of this bridge first on falsework or by pontoons and then to erect the central span without falseworks, using the side spans as cantilevers to hold up the weight of this central span.

NORTH RIVER BRIDGE.

Various plans have been proposed for crossing the North River at New York City. One of these is by a tunnel which has been for several years under construction. This will be a double track tunnel. A bridge has been proposed high enough to allow ocean navigation to pass under it and with one pier in the center of the river. The best design, however, and one which no doubt will meet with the least opposition from the navigation interests and from the Government is that of Mr. Lindenthal who has proposed a bridge without a pier in the river. The river at the point where the bridge is proposed to be built is about 2850′ wide. The bridge will be a stiffened suspension bridge with a main or middle span 2850′ long and side spans of 1500′ each; the height above the water will be 155′, total length of the bridge 6,500′, the height of the anchorages 210′, the height of the towers above the water 500′ and the deepest foundations below high water 190′. The bridge is to have from six to ten tracks. There will be four cables used each of which will be 48″ in diameter, the area of which will be about ten times that of the Brooklyn bridge, the latter being 15½″ in diameter; the width of the bridge is to be 85′, the towers at high water mark 340×180′. The structure will be built entirely of steel.

The plans have been quite carefully worked out and there is no doubt of the entire practicability of the structure. The only question is a financial one. The vast increase of population and business of all kinds and the growth of our country (which will always make New York its metropolis) now demand a bridge fully as adequate as this is proposed to be with its ten tracks. The time will soon come as at the Detroit River when the world will no longer be willing to stand on the banks waiting for a passage.

THE IMPROVEMENT OF RAILWAY TERMINAL FACILITIES AS RELATED TO THE TRANSFER OF COARSE BULK FREIGHT.

By Edward Lindsley, Member of the Civil Engineers' Club of Cleveland.

[Read February 11, 1890.]

Reviewing the development of artificial illuminants from such primitive forms as pine knots and the like to those of more modern date, a correspondent of a technical journal concluded that the civilization of a people might be fairly judged by the refinement of their methods in the use of artificial illuminants. This may or may not have been a logical conclusion. But may we not safely estimate the business activity of a nation by the measure of its transportation facilities? Men now living can recall the time when there was not one mile of railway track used for passenger traffic in the United States. Your writer can remember when the mileage was less than fifty miles. In those days two or four-wheeled vehicles, with horses, mules or oxen for the motive power, were largely used for inland transportation and passenger traffic, and for the most part over dirt roads, the best of which were dignified as turnpikes. Here and there between certain principal and ambitious business centers a sort of maritime affair called a canal was installed, upon the bosom of which floated craf also dependent upon animal power for motion, but capable of carrying enormously increased loads, say, from thirty to sixty tons. These canal liners, but more especially the improved packets, were also speedy affairs, annihilating distance after a marvellous fashion, plowing through the waters at the rate of from three to six miles per hour. When the first packet service was fully installed on the Erie Canal the time required to journey from the heart of New England to the far West, *i. e.*, to the Western Reserve, was reduced from an uncertain large number of days to seven and sometimes even less. Fifty or more years ago the transportation of freight and passengers on the high seas or inland lakes was effected chiefly in sailing vessels. On the ocean a square-rigged vessel capable of carrying 500 tons was a mammoth, while a vessel of 150 tons was a lake-carrier of magnificent proportions. But what have a few years wrought? Once

fairly harnessed, there seemed no limit to the possibilities of steam. Between New York and Liverpool Grinnell's packets covered the distance eastward in twenty or thirty days and westward in forty to sixty or more days. To the ocean racer of to-day it is a matter of indifference whether the passage be to the East or West; in either case, it is made within the week. If the journey be a Western one, when the steamer arrives at New York instead of a stage coach or canal packet, the passenger takes a vestibule train for the "far West" and gets there inside of a week, notwithstanding it has moved from the Western Reserve to the Golden Gate.

Indeed, the ideal fancy of Jules Verne's, or "Around the World in Eighty Days," has been more than realized almost within the year but just begun. That the changes wrought in transportation facilities within the fifty years past are by no means least among the wonders of the nineteenth century goes without saying. That many magnificent industrial enterprises we now see about us would have been impossible without them is undoubtedly true.

We say that effect follows cause, but we are sometimes at a loss to determine where the one leaves off and the other begins, or in other words, which is cause and which effect; and so in the improvement of railway terminal facilities as related to the transfer of coarse bulk freight, the words "transfer" and "transportation" have come to sustain almost interchangeable relations, the distance that once embraced a series of transfers having become a single, continuous line of transportation. The long trunk lines of railway transportation are, in many instances, made up of what was originally a number of short local lines installed to meet local necessities and constructed without the slightest reference to interchange of rolling stock, the gauge of the rails ranging variously from 2 to 6′. Under this regime it soon came to be seen that in many instances the cost of transfer largely exceeded that of transportation, and progressive men with brains early sought to consolidate lines under a single management and with a uniform gauge of track. Of course local interest, short-sightedness and other imbecilities prevented as rapid a consummation of such schemes as might have been desired. It was, however, but a question of time when these and other impediments to railroading on a grand scale would be removed, and the growth of the railway system in the United States progressed at a rate unparallelled elsewhere. It is no part of the writer's purpose to detail the improvements in railways or their equipments, except as they may be connected with terminal facilities for the transfer of coarse bulk freight.

A month ago an able railway authority gave us some strong points bearing upon this subject, from which it is easy to infer that while much has been done, much still remains to be done in the way of facilitating the transfer of bulky freight from car to vessel or vice versa. The largest transfer operations are confined to the point of meeting of water and land carriage. A vast amount of study and ingenuity has been expended in devising special cars for special purposes, also hoists, cranes and derricks, and all the outgrowth of an appreciation of the importance of and necessity for cheaper and more expeditious transferring mechanism.

Among the coarse bulk freights iron ore and coal may be mentioned

as of first importance. Muscle, always comparatively cheap, is usually the first resort in handling them, and in primitive days was the main dependence, whether derived from biped or quadruped sources. The appliances through which results were obtained were of the simplest character, for the former a shovel and barrow, while the latter operated a tub by means of a line and a few simple pulleys. The inexorable demands of economy, supplemented by sharp competition, however, soon called for a more excellent way, and man sought out many strange inventions to encompass the desired end. So that, in describing a freight dock at this time it is far easier to say what it is not than what it really is. It is not a simple platform along which a vessel may lie and discharge or receive freight, or over the surface of which railway cars may be placed for loading or unloading. It is a platform, truly, but the array of engines, hoists, cranes, derricks, pockets, &c., are so numerous that the original simple dock is almost lost to view. All these appliances have not been evolved by a simple chain of reasoning, neither have the original adaptations always been maintained. In some instances the original design and mode of operation have been exactly reversed.

Iron ore and coal have been mentioned as specimens of coarse bulk freight of first importance; may they not be justly so considered when we remember that in 1889 an aggregate of about twelve million tons of these two commodities were transferred at Lake Erie ports alone, and the coal included in that figure embraces only the bituminous article. If three or four cents per ton can be saved in transferring this tonnage, may it not be regarded as a decided improvement in terminal facilities? For a better understanding of the present situation and that which may obtain, let us briefly review some of the steps that have led to present conditions, and inasmuch as the shipment of bituminous coal is attended with some complications not connected with handling ore or anthracite coal, what follows will be written with special reference to that commodity.

Lake vessels carrying two thousand tons are by no means the largest, while there is a strong tendency to further increase in size, which means so large an investment in a single hull that no matter what the freight rate, expeditious loading must obtain to permit satisfactory financial returns. Anthracite and ore may be and are successfully loaded from pockets and expeditiously unloaded by hoists and conveyors; not so with bituminous coal; the damage to the product by discharge from deep pockets, to say nothing of that which arises in putting it into those pockets, is so great that modern practice has settled down to the following plan for loading ships: Briefly, human muscle applied through the shovel transfers the coal from cars to bucket; by means of hoist or derrick the bucket is raised above the ship rail, conveyed to a point over the hatch and lowered into the hold instead of being overturned at a great height. Save one, these operations seem in themselves capable of realizing all that can be desired. The defective one is the first, viz: filling the buckets, and this is faulty as to destroy the efficiency of all the rest and rule bituminous coal out as a desirable freight.

Suppose a twenty-five hundred ton ship moored at the dock, upon which or as near thereto as circumstances would permit are located one

hundred or more freight cars loaded with coal, which is to constitute the freight of the aforesaid ship. Let us consider what pertains to filling the buckets. The minimum price of such work may be stated at six cents per ton, and the amount required to move the tons in question, $150. But inasmuch as the shovelers strike the gait for the other operations, we may mention that the standing track room required at the start will be about one mile, and the time required to relieve it, as well as the cars and vessel, not less than two days. Considering fifty tons per day a man's work and twenty-five men the number that may be advantageously employed on this part of the operation, we have two days in which to make the transfer. Owing to interruptions and delays that inevitably occur such a result will rarely obtain in practice, but the time will be nearer three than two days. The result is, that vessels like the one supposed, are not generally the coal carriers. The tonnage handled per foot of dock front is, to say the least, unsatisfactory, and does not compare with results obtained in handling ore or anthracite, and the railways find it difficult to transfer at their terminals such amounts of freight as they can easily move between those points. The solution has often been sought in the direction of a modified car, the car before being modified was usually a gondola car, one of the oldest, and in its original simplicity was the best and most generally useful forms of railway rolling stock ever devised.

That no one misunderstand, pardon a brief description: A platform having side and end boards but no top, simply an open box, mounted on two or three four-wheeled trucks, and provided with suitable brake mechanism, constitutes the gondola car of to-day, which is like the same car as constructed in primitive days, except in the matter of size. Ten tons was a load for an old-time gondola. It is not uncommon now to see such cars with "Capacity Sixty Thousand Pounds," painted upon their sides. On roads whose freight is largely coarse and bulky these cars are very numerous, and when the freight is largely ore and coal they probably outnumber all other forms. They are adapted to carry a wide range of articles, besides ore and coal, such as brick, stone, lumber, building materials generally, heavy machinery, and indeed almost any bulky material that could not go in a house car, and that need not be protected against the weather. It may carry forms of freight that could be mounted on no other style of car. It has been made the base of many attempted and some real improvements. The sides and ends have been hinged; the floor corrugated, wedged or trapped, or the entire body made to assume an angular position toward either side for unloading purposes. While some of these changes may have proven advantageous under certain conditions, the fact remains that for general utility the gondola car pure and simple, fills the widest range of usefulness. No matter in what direction it goes, if there is anything to be carried that can ride, it can carry it. To Pittsburgh it may carry ore, and from Pittsburgh it can carry coal. It need not go empty in either direction.

From the foregoing, it appears that this ideal car has been trebled in carrying capacity. It may be questioned whether further increase in size could be advantageously made. Doubtless the sides should be no deeper while other conditions remain as they are. Indeed, parties contracting to

empty these cars when loaded with coal have already sought to discriminate against those of the deepest sides, objecting to the great lift required to carry the load over the side. As previously indicated, steam derricks, hoists and conveyors have been provided that leave little to be desired in the way of moving the loaded bucket either vertically or horizontally. But when there is any considerable amount of this work to be done, steam should be made to fill the bucket as well. Economy and common humanity demand it, and the solution of the problem is believed to be comparatively easy. Briefly, dispose the loaded car promptly, that is, invert it, as you would any other receptacle to be emptied of its contents, and let gravity do the rest.

To that end, having selected a suitable situation, preferably on a side track, provided a cylinder of sufficient length and diameter to receive the largest car, remove a sufficient section of the side track to accommodate the length of cylinder. Within the cylinder, along its lowest side, arrange a platform with rails thereon in alignment with approaching rails at either end. About the circumference of the cylinder have ring-shaped guide rails resting in grooves or grooved spools, so supported as to sustain the cylinder and its load and permit the whole to rotate about the longitudinal axis. Provide the platform, in the cylinder with suitable elevating mechanism, so that after the loaded car is rolled into the cylinder it may be elevated and the top rail of its box brought into contact with stops along the upper side of the cylinder. This done, drive horizontal clamping bars against either side of the car so as to securely hold it in place no matter what the position of the cylinder, which may now be given a half revolution; this done the contents of the car rest in the inverted roof of the cylinder, but five or six feet lower than when they entered.

The portion of the cylinder that constitutes the roof is provided with sliding shutters, while beneath this construction buckets are grouped of sufficient size to accommodate the load, and when the shutters are opened the buckets receive it. The arrangement of the buckets is effected either by the construction of a pit beneath the cylinder in which to work them, or by elevating the cylinder above the ordinary level, the cars being received and delivered by means of inclined approaches; in either way the end sought is accomplished cheaply and expeditiously, the cars are unloaded into buckets if so desired, or to a stock pile if preferred.

A better idea of this construction may be obtained from drawings which are here for the inspection of those who desire to see them, and from this model which has been seen by some present before, but which is here now at the request of the Programme Committee.

The after manipulation of the buckets may be, under some conditions, a matter of interest, but nothing particularly new in that direction is contemplated. The tons of coal per day that may be transferred in this way will depend upon the size of the cars; large cars, on account of the shorter hoist required in the cylinder, will be handled with more expedition than small ones, but it is believed that from three to five minutes is abundant time for unloading a car, and the men required to manipulate it not to exceed four.

REQUIREMENTS OF SPECIFICATIONS FOR STEEL AND IRON.

By James Ritchie, Member of the Civil Engineers' Club of Cleveland.

[Read February 11th, 1890.]

This subject is one which could be discussed at great length, but would occupy too much space and time for the limits of this paper. The writer has endeavored to show a few of the points which should be included in specifications for quality of material only, and to give a few reasons for the use of such requirements.

Engineers have gradually made their specifications, especially for steel, more rigid and more comprehensive in their requirements; they call for higher grades with each new specification, and as the engineers increase their demands, the manufacturers put in the necessary machinery to comply with them. Engineers should bear in mind that the strain a piece of iron or steel will bear depends on the amount of rolling or forging which it receives. A fair quality of iron is that specified in the Bridge Builders' Standard Specifications, which make the ultimate tensile strength depend upon the area of section and the circumference of the piece, as indicated by their formula for ultimate strength in pounds per square inch, viz: $52000 - \frac{7000 \times \text{area}}{\text{circumference}}$ for tension members and all iron except plates over 8″ wide and shaped iron. Plates between 8 and 24″ are required to have an ultimate strength of 48,000 lbs., and over 24″ wide of 46,000 lbs. per square inch. All shaped iron is specified to have an ultimate strength represented by $50000 - \frac{7000 \times \text{area}}{\text{circumference}}$. The results of these formulæ give quantities in conformity with the class of material manufactured by the best rolling mills of the country.

Great care must be taken in determining the elastic limit and elongation of the material,—the qualities which should be regarded as determining the allowable strain on tension members; 26,000 lbs. per square inch is generally taken as the lowest elastic limit allowed by the best authorities. The allowable elongation varies from 12 to 25 per cent., according to the section from which tests are taken. One of the most important points to look after for surface defects is the inspection, which is the most difficult to thoroughly accomplish.

Rolling mills usually have very little spare yard room for inspection of material, thus making it necessary to hurry the surface inspection in order to clear the yard, but with proper care the surface inspection can be done very satisfactorily.

A very important test of steel and iron is the cold bend test, which

should be required for all specimen tests. In the tensile tests wrought iron should show a strictly fibrous fracture, and in general must be tough and easily welded, and should show no weld marks after being cooled.

A sufficient number of tests should be made to fairly represent the sizes of the material ordered and the number of full size tests should be sufficient to represent the eye-bars or tension rods; usually about one bar in fifteen or twenty is considered a fair proportion.

Steel should have much more rigid inspection than iron, and should be rejected for much less important appearing defects. A steel eye-bar having any defects within three feet of either end before the heads are made, should be rejected, as the upsetting of the same will tend to increase the size of the defects, while in iron bars the piling and forging of the heads will be more likely to remove them. It is customary to require two tests from each heat or blow of steel, one being a ¾″ round rolled from a small test ingot, which is poured as nearly as possible from the middle of the melt, and the second is cut from finished material, so as to represent as nearly as possible the different sizes of the same. These specimens are tested for elastic limit, ultimate tensile strength, elongation, reduction of area and bending cold.

The elastic limit of steel should be not less than 40,000 lbs. per square inch for high grade steel, 36,000 lbs. for medium steel and 30,000 lbs. for soft steel.

The ultimate tensile strength of high grade steel should range between 70,000 and 80,000 lbs. per square inch; of medium, between 60,000 and 70,000, and of soft, between 52,000 and 60,000 lbs. per square inch.

The elongation in 8″ length should be not less than 18 per cent. for high grade, 22 per cent. for medium and 25 per cent. for soft steel. The reduction of area at point of fracture should be not less than 35 per cent. of the original area. High-grade steel should be used for compression, bolsters, bearing plates, pins and rollers.

Medium steel should be used for tension members, floor system, laterals, bracing, portals and, unless high-grade steel is specified, should be used for all steel members except rivets.

Soft steel should be used in rivets only, and should be tested by actually making up into rivets, riveting two plates together, and upon being nicked and cut out, should show a good, tough, silky structure with no crystalline appearance. Rivet steel should not have over $0.^{15}/_{100}$ per cent. carbon.

Steel made by the Bessemer process should not have over 0.08 per cent. of phosphorus and open hearth steel not over $^{1}/_{10}$ of 1 per cent. The amount of phosphorus allowed should always be stated in the specifications, as this determines the price of the pig iron required to make the steel.

About 0.04 per cent. of sulphur is allowable and sometimes more. Excessive sulphur in steel or iron causes the same to be "red short;" that is, it can not be hammered or forged at or above a red heat, but can be worked below that heat, while excess of phosphorus causes the metal to be "cold short" or incapable of being worked at or below the temperature of dull red heat.

Analysis should be required of each melt showing the amount of carbon, manganese, phosphorus and sulphur in the steel, and these analyses would better be made from drillings taken from the finished material.

The writer hopes to see the Specifications of Bridge Engineers made of a uniform character, which can be easily complied with, and which will be based upon a thorough knowledge of the physical metallurgical and chemical qualities of the material.

DISCUSSION.

N. B. WOOD.—Do you advise putting into any structure steel rivets of any kind?

MR. RITCHIE.—Yes, sir, I would put steel rivets into any structure of steel. The right kind of steel rivets are as good as any others.

MR. HOLLOWAY.—The question is a very reasonable one, when we think of steel as it used to be made. The only difficulty now is to tell what is steel and what is iron. A structure of steel as now made is much better than one previously made. It is so acknowledged generally. It is a term which is very broad and very apt to mislead most of us, who know of steel as high-grade steel and tempered steel, and that many acknowledge it in many respects as being unreliable.

The facts are, that metal known as steel made by open-hearth or even Bessemer process, is really nothing but refined iron.

The best authorities we have on that score have come to this conclusion that iron is a material which is made by being puddled, welded and rolled. Steel is made by being melted and poured. In wrought iron, made as it is by being puddled, many impurities are always interfering with the strength, which prove very disastrous in using it for boiler plates. But we get some good features in steel without any difficulty from imperfect welding, etc. At the present day steel rivets are put in by hydraulic machines, thus avoiding hammering of the head. The red hot rivets are simply squeezed up in place without causing any change in their molecular structure, thus avoiding the objection to their use, to which Mr. Wood refers.

MR. WOOD.—I am somewhat in this steel business myself, and I think I know what I am talking about. I think I see just as good steel as anybody. When we make rivets of steel the head is almost always liable to fly off unless annealed. Iron is so peculiarly different that it will not break. If it were my structure I would not have a steel rivet put in it under any consideration. Steel is steel, and iron is iron, and you cannot make one into the other. The difference in working steel and iron is very great, and whenever you begin to hammer steel you begin to change its structural character.

We all know of the difficulty occurring here in the screw works when they thought it would be a great thing to make screws out of steel instead of iron, but they found that the heads would fly off. Where the part that is

hammered is joined on to the part that is not hammered there is a great deal of disagreement. When steel forges were first introduced and steel plate made for the purpose of building boilers, people thought that by taking a steel plate it would show up well, and that, as it had high elastic limit, they had got hold of something far superior for boiler plate. They used it without knowing that when you begin to work on one part of steel it makes a great change in its character. I have known steel boiler plates that were flanged, and appearing to be a very excellent job, and in the morning the man in charge would find them cracked in two. This was afterwards avoided by annealing. After steel has been annealed it is much safer.

MR. PORTER.—I think Mr. Holloway has touched the right point, at least in one instance—that steel rivets are for the most part upset by machine. We have now a contract that will take perhaps 100 tons to furnish. The structure of the rivet does not seem to be injured by the machine as when it is upset by hand. I think there is no trouble with steel rivets when put in properly, but do not think I would have any field rivets put in in steel.

MR. FORCE.—I think that engineers should be independent and make their own specifications. The best requirement should be uniformity in drawing them up.

MR. EISENMANN.—We frequently take up specifications and see one part incomplete. I think a standard of uniformity should be sought for in our specifications. Of course there is no use calling for anything that cannot be complied with.

MR. RITCHIE.—If engineers would make their specifications more severe the manufacturer would be more apt to comply with it. We can make two tests of the same steel, which will be quite different. A ¾″ round well-rolled down may come up to the specifications. The finished material from the same melting of steel will probably not come up within 10 per cent. of that limit.

MR. PORTER.—The best of engineers put in saving clauses that ¾″ round shall receive a given amount of work.

MR. GOBEILLE.—That is a good idea in Mr. Ritchie's paper, that consistent specifications would tend to make manufacturers more honest.

DEFLECTION OF FRAMED STRUCTURES AND THE DISTRIBUTION OF STRESSES OVER REDUNDANT MEMBERS.

By J. B. Johnson, Member Engineers' Club of St. Louis.

[Read January 8, 1890.]

The analysis of all sorts of stresses in framed structures for all kinds of loads has become a very trite subject with bridge engineers. Every school boy is now so thoroughly versed in the fundamental principles of mechanics which apply to framed structures and the books give this information so completely, that there is little to say in that field. There are, however, some problems concerning the action of structures under loads which are as yet little understood.

I propose here to discuss a method of finding the deflection of any point in a framed structure for any given loading, and to show that this information may be used to determine stresses in redundant members, otherwise indeterminate.

Proposition I.—*The external work of distortion of a framed structure by a load, is equal to the internal work of resistance.*

This proposition hardly needs proof, as it is more or less axiomatic. When granted it enables us to prove the second proposition.

Proposition II.—*The deflection of any point in any framed structure subjected to any given load is given by the formula:*

$$D = \Sigma \frac{p\,u\,l}{E} \qquad (1)$$

Where

D = deflection of point under consideration.
p = stress per sq. in. in any member for given load.
l = length of any member.
E = modulus of elasticity of any member.
u = factor of reduction.
Σ = sign of summation.

That is to say that the quantity $\frac{p\,u\,l}{E}$ is computed for every member of the truss and the algebraic sum taken as the total deflection of the point.

Proposition III.—*When there are two or more paths over which a load may travel to reach the support, the load divides itself among the several paths strictly in proportion to the rigidities of the paths.*

The relative rigidities of the paths are indicated by the relative loads required to produce a given deflection, or they are inversely as the deflections produced by a given load which is required to pass wholly over each path in succession. Having established this proposition and com-

puted the rigidities of the paths by Prop. II. we can write enough equations of condition to enable us to solve for any number of redundant members. This proposition applies to all structures, whether framed or composed of masonry, as in the case of a curved masonry dam.

Proof of Propositions.

Proposition I. hardly requires proof. It is simply expressing for the work or energy spent on the structure that which we take for granted as to the force coming upon it, that is to say, action and reaction are equal. The external work of distortion is the product of the load into the deflection of the loaded point divided by two. The internal work of resistance is the sum of the products of the stress produced in each member by its distortion, divided by two.

Thus if W is the external load.

and D the deflection of the loaded point.

P the stress produced in any member.

z the distortion of any member due to the stress P.

Then we would have

$$\frac{W D}{2} = \Sigma \frac{P z}{2} \tag{2}$$

where the second member represents the algebraic sum of the quantities $\frac{P z}{2}$ computed for all the members of the truss for the load W.

From the above it would appear that the total deflection D at the loaded point is made up of as many parts as there are members in the entire truss, each one contributing its portion, corresponding to the expression $\frac{P z}{2}$ for that member. If we represent that portion of D, the total deflection, resulting from the distortion in one member by d, then we may say the part of the work done at the loaded point corresponding to the work of resistance in any particular member is

$$\frac{W d}{2} = \frac{P z}{2} \text{ or } d = \frac{P}{W} z \tag{3}$$

Or, we might have assumed the structure perfectly rigid except one member. Then all the deflection at the loaded point, d, is due to the distortion, z, of the one elastic member. To persons familiar with the calculus we would say that the total differential, (change), of the function, (deflection), of several variables, (members of the truss), is equal to the sum of all the partial differentials obtained by successively assuming all the variables to be constant except one.

Referring now to equation (3) we see that the deflection of the point in question, due to the change, z, in the length of any member, is equal to that of the change, z, multiplied by the ratio of the resulting stress in the member, P, to the load, W, at the point. Since the change of length, z, may be any small change of length, and not that due to the load, W, at all, but simply the change for which the resulting deflection is to be obtained, it is of course the elastic distortion due to the working load in the bridge. But if p is the unit stress in the member for this working

load, l the length of the member, and E the modulus of elasticity, then we have

$$z = \frac{p\,l}{E}$$

Also, since W may be any load placed at the loaded point, we may make it *1 pound*, and then calling the resulting stress in the member, due to this 1 lb. placed at the point, u, we have

$$\frac{P}{W} = \frac{u}{1} = u,$$

hence equation (3) becomes

$$d = \frac{p\,u\,l}{E} \tag{4}$$

or the deflection, d, of any point in a structure due to the distortion $\frac{p\,l}{E}$ of any one member from internal stress, is equal to that distortion multiplied by the stress, u, (really the ratio $\frac{P}{W}$) in the member, caused by placing one pound at the point in question.

The total deflection of the point is therefore the sum of all its parts, or

$$D = \Sigma \frac{p\,u\,l}{E} \tag{5}$$

Hence follows Proposition II.

When the point whose deflection is desired is the middle point of a truss both p and u will always have the same sign for all members, when the bridge is fully loaded, and hence their product will always be positive. If any other point be chosen, or if the load be an unsymmetrical one, this product may be negative in a few cases, where the algebraic sum must be taken.

In applying this in practice, we always know p, the unit stress in every member, for the assumed load on the structure, also its length l, and its modulus of elasticity E. It remains therefore only to find u for every member. Since this is a pure ratio, equal to the stress in that member for one pound placed at the point, we simply put 1 lb. at the point whose deflection is desired and find the resulting stress in every member, either analytically or graphically. This then is to be considered as an abstract quantity, being in fact a pure ratio, and the factor of reduction by which the distortion $\frac{p\,l}{E}$ of each member is reduced to the resulting deflection of the point. This point would usually be the end of a cantilevered arm, as in a swing bridge, or the middle point of a truss supported at the ends. It may, however, be any point, and the truss may be of any design, so long as the stresses are all direct tension and compression. The formula can take no account of any bending stresses nor of any lost motion at joints.

A common method of computing deflections is to take account only of the stresses in the chords. This gives very erroneous results as the deflection due to the web stresses will be found to about equal to that due to the chords.

This formula may be applied to all kinds of trussed forms. The writer

recently applied it to various forms of trussed brake-beams, and his figures were confirmed almost exactly by the subsequent tests.

The load on the truss may be any assumed load whatsoever, for which p, the unit stresses, are computed. But the one pound load, for finding u for each member must be put at the point whose deflection is desired,*

The truth of Proposition III. is also nearly self-evident. If the paths be conceived as india-rubber, all taut and ready to act in resisting distortion, then for a given distortion the load will divide itself over the parts in porportion to the several resistances to distortion. But the degree of resistance to a given distortion is a measure of the rigidity of the body. Hence we may say the load divides itself among the paths in proportion to their respective rigidities.

THE DETERMINATION OF STRESSES IN REDUNDANT MEMBERS.

The above ready method of computing deflections accurately, together with the use of the principle expressed in Proposition III. enables us to find the stresses in redundant members, or in other words to solve any composite system, however many combinations there may be in it. To do this we must compute the deflections of each elementary system for a given load. The reciprocals of those deflections represent the relative rigidities of the different combinations, and since the load is to be divided in proportion to these reciprocals, we thus obtain one less number of equations than we have systems. The other equation results from the sum of the parts equaling the whole. This then gives us as many equations as there are systems and we can determine what part of the total load passes over each combination; and hence solve for the stresses in such combination. If any one member forms a part of two or more combinations, the total stress in it is the sum of all the stresses caused by the several combinations of which it is a part.

The application of the formula $\frac{p\,u\,l}{E}$ and the solution for redundant members will be illustrated by an example. (See figures on next page.)

By putting in the members $A\,G$, and $B\,G$, Fig. 1, the system becomes composite. The first system is shown in Fig. 2, and the second in Fig. 3. The members $A\,B$ and $G\,D$ are common to both systems.

The lengths of the members are given on the left half and the values of u for 1 lb. placed at D are given for all the members on the right half of Figs. 2 and 3.

If the joints C and E are true joints then the second system, $A\,G\,B\,D$ would assist in carrying only the load at D, and no part of the loads at C and E, when the two systems were in combination, as shown in Fig. 1.

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*This elegant proposition in framed structures was first published in America by Prof. Geo. F. Swain, in the Journal of the Franklin Institute, April, May and June, 1883. He there gives a historical note concerning it, crediting its origin to Lame, but afterwards amplified and given extended applications by Maxwell and Jenkin in England and by Mohr and Winkler in Germany.

Prof. Swain applies it to the solution of various styles of trusses, particularly to arches and continuous girders.

Probably its principal use is in simply computing deflections, from which, by the aid of Prop. III. redundant members may be solved.

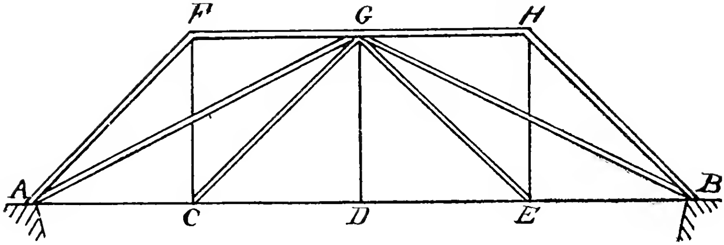


Fig. 1

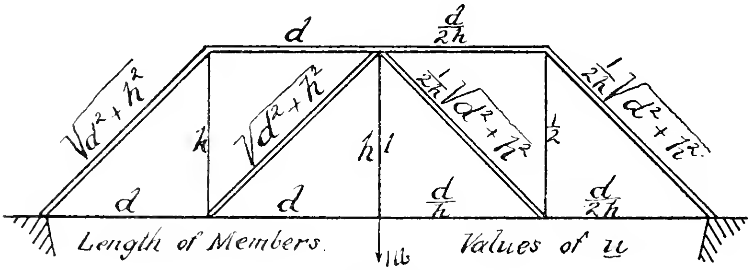


Fig 2.

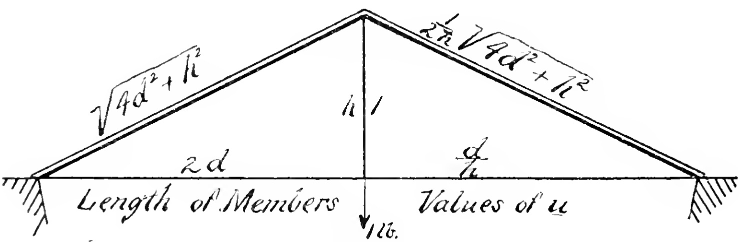


Fig. 3.

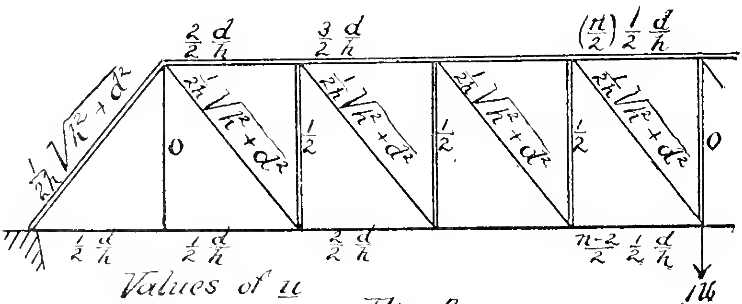


Fig. 4

The problem then is to find what part of the load at D goes on each system.

By Prop. III. the load at D will be divided between the two systems directly as their rigidities, or inversely as their deflections for any given load. But when the joint D is fully loaded we may suppose the whole bridge is fully loaded. In this case all the members would have their working unit stresses which may be supposed to be the same, as p_t for all the tension members and p_c for all compression members in the combination. At least the parts should be proportioned to give nearly these uniform values, and it will be here assumed that they have them.

Since we wish the deflection at the point D, we put the 1 lb. load there for finding u, the resulting stress in each member. These values are given for both systems on the right hand portion of the figures.

The lengths also being there given, and p_t and p_c and E being known we may write at once the values of $\frac{p\,u\,l}{E}$ for each member.

Thus for the first truss we have

$$\text{For lower chord,}\quad \frac{p\,u\,l}{E} = \frac{3\,d^2}{h} \cdot \frac{p_t}{E}$$

$$\text{For upper chord,}\quad \text{“}\quad = \frac{d^2}{h} \cdot \frac{p_c}{E}$$

$$\text{For verticals}\quad \text{“}\quad = 2\,L\frac{p_t}{E}$$

$$\text{For inclined struts,}\quad \text{“}\quad = 2\Big(\frac{d^2 + h^2}{h}\Big) \cdot \frac{p_c}{E}$$

Whence the total deflection of the first truss, for a full working load, producing the unit stresses p_t, and, p_c is

$$\text{Deflection} = \Sigma\,\frac{p\,u\,l}{E} = \frac{3\,d^2 + 2\,h^2}{E\,h}(p_t + p_c) \qquad (6)$$

For the second truss, for a full working load, producing the unit stresses p_t, and p_c in its parts we have

$$\text{For the lower chord,}\quad \frac{p\,u\,l}{E} = \frac{4\,d^2}{h} \cdot \frac{p_t}{E}$$

$$\text{For the vertical,}\quad \text{“}\quad = h \cdot \frac{p_t}{E}$$

$$\text{For the inclined struts,}\quad \text{“}\quad = \frac{4\,d^2 + h^2}{h} \cdot \frac{p_c}{E}$$

Whence for the entire truss, the deflection is

$$\text{Deflection} = \Sigma\frac{p\,u\,l}{E} = \frac{4\,d^2 + h^2}{E\,h}(p_t + p_c) \qquad (7)$$

These two deflections are equal, as seen in equations (6) and (7) when $3\,d^2 + 2\,h^2 = 4\,d^2 + h^2$, or when $d = h$. In this case the load at D would divide itself equally between the systems.

Let us suppose, however, that $d = 1.5\,h$. In this case the

$$\text{Deflection of first truss} = 8.75\,\frac{h}{E}\,(p_t + p_c)$$

$$\text{and}\quad \text{“}\quad \text{“ 2nd}\quad \text{“}\quad = 10\,\frac{h}{E}\,(p_t + p_c)$$

Whence $\frac{1000}{1875}$ of the load at D would go on the first truss and $\frac{875}{1875}$ of it on the second truss.

From the above it is evident that for any given combination of members, and for any given system of loads, it can be determined what portion of the total load goes on each system, and hence what the stresses are in every member.

DEFLECTION FORMULA FOR A PRATT TRUSS.

For approximate or working values of the deflection of any style of truss we may obtain a formula which is readily evaluated, provided we may assume some average values for intensities of the tensile and compressive stresses. Thus for a Pratt truss, single intersection of an even number of panels, we may use p_t for the mean tensile stress and p_c for the mean compressive stress, E for the modulus of elasticity, d for the panel length, and h for the height of truss, and n for the number of panels, and obtain:

$$\left.\begin{array}{lll} \text{For the Upper Chord} & \Sigma \dfrac{p\,u\,l}{E} & = \dfrac{p_c d^2}{8\,E\,h}(n+4)\,(n-2) \\ \text{For the Lower Chord} & \text{"} & = \dfrac{p_t d^2}{2\,E\,h}(n\,(n-2)+8) \\ \text{For the Web Tension M's} & \text{"} & = \dfrac{p_t}{2\,E\,h}(n-2)\,(h^2+d^2) \\ \text{For the Hip Struts} & \text{"} & = \dfrac{2\,p_c}{2\,E\,h}(h^2+d^2) \\ \text{For the Verticals} & \text{"} & = \dfrac{p_c h^2}{2\,E\,h}(n-4) \end{array}\right\} \qquad (8)$$

Whence for the whole truss, the total deflection of the middle point for a full load is

$$D = \Sigma \frac{p\,u\,l}{E} = \frac{p_t + p_c}{2\,E\,h}\left[(n+2)\frac{n\,d^2}{4} + (n-2)\,h^2\right] \qquad (9)$$

Where p_t = average unit stress of tension members.
p_c = average unit stress of compression members.
E = modulus of elasticity for all members.
h = height of truss in inches.
d = panel length in inches.
n = number of panels in bridge.

It will be noticed that in this case there is nothing to sum but u for each member, as grouped above in Eq. (8), p, l, and E, being constant for all the members of a group. Also, for such members as give a value of $u = o$, as for the middle vertical and the end hanger, they are of course omitted, or rather count for nothing in the summation. This means that these two members do not in any way contribute to the deflection of the middle point.

Numerical Example.

Take a Pratt truss, 200 feet span, of 12 panels, with a height of 400 inches, or 33 ft. 4 in. the panel length being 200 inches. If the average maximum tensile stress for both dead and live load be taken as 10,000

lbs. per sq. in. and the average compressive stress as 7,000 lbs. per sq. in. the total deflection is readily found from Eq. (9) to be 2.49 inches.

Relative Deflection from Web and Chord Stresses.

By adding the deflection increments due to web members, and those due to chord members, we may obtain

$$\left.\begin{aligned} &\text{For Chords } \Sigma\frac{p\,u\,l}{E} = \frac{d^2}{8\,E\,h}\left[\,(n\,(n-2)+8)\,p_t + (n+4)\,(n-2)\,p_c\right] \\ &\text{and for Web } \quad `` \quad = \frac{p_t}{2\,E\,h}\left[\,(n-2)\,(h^2+d^2)\,p_t + \left((n-2)h^2+2d^2\right)p_c\right] \end{aligned}\right\} \quad (10)$$

If we should assume the average stress in the compression members is 0.7 that in the tension members, or $p_c = 0.7\ p_t$ we may write

$$\left.\begin{aligned} &\text{For Chords } \quad \Sigma\frac{p\,u\,l}{E} = \frac{p_t\,d^2}{8\,E\,h}\,(1.7\,n^2 - 0.6\,n + 2.4) \\ &\text{and for Web } \quad `` \quad = \frac{p_t}{2\,E\,h}\,(1.7\,n - 3.4)\,h^2 + (n - .6)\,d^2 \end{aligned}\right\} \quad (11)$$

Whence

$$\frac{\text{Deflection from Web}}{\text{Deflection from Chords}} = \frac{(6.8\,n - 13.6)\,(\frac{h}{d})^2 + 4n - 2.4}{1.7\,n^2 - .6\,n + 2.4} \qquad (12)$$

This ratio increases as $\frac{h}{d}$ increases by the law of the common parabola, and decreases as n, the number of panels, or length of bridge, increases.

For a Pratt truss bridge of 200 feet span, of 10 panels, and a height of 30 feet, this fraction becomes $^{80}/_{83}$ or 96.4%.

That is to say, for such a span and for the assumptions made, the deflection from web distortion is about equal to that from chord distortion.

A Whipple truss is simply a pair of Pratt trusses joined into a double intersection system and hence the deflection of the combination is to be computed by taking one of the systems alone.

Thus for such a bridge, 400 ft. long, with 20 panels of 20 ft. each, the panel length for one system would be 40 ft. Let the height be 60 ft., whence we would have $n = 10, d = 40, h = 60$.

For this case equation (13) would give exactly the same as before, since n is the same and $\frac{h}{d}$ gives the same ratio.

For the case when $\frac{h}{d}$ is large and n small, as for a bridge say of eight panels, of 15 ft. each, with a height of 25 ft. we should find

$$\frac{\text{Deflection from Web}}{\text{Deflection from Chords}} = \frac{142.8}{106.6} = 1.34$$

That is for such a case the deflection from the web system is 1.34 times that from the chord system. On the other hand, if the height is about equal to the panel length, and the number of panels is large, as for instance, $n = 12$, and $h = d$, then we would find that

$$\frac{\text{Deflection from Web}}{\text{Deflection from Chords}} = \frac{28.4}{60} = 0.47$$

Or, in this case, the deflection from web would be only about half that from the chords, or one-third the total deflection of the bridge.

In general, it may be said that the deflection of a truss bridge from the web stresses is about equal to that from the chord stresses.

This is directly contrary to the generally received opinions of engineers, who generally assume that the deflection from web stresses is relatively insignificant. It is probable that Mr. Stoney is largely responsible for this generally accredited opinion. In his two volumes on strains he undertakes to prove that this is the case, and he used for a frontispiece the supposed graphical proof of this proposition, thus strongly emphasizing this very erroneous belief.

To find the effect on the deflection of changing the height of the truss everything else remaining the same, we may differentiate equation (9) for h variable and find

$$\frac{dD}{dh} = \frac{p_c + p_t}{2\,E}\left[-\frac{(n+2)\,n\,d^2}{4\,h^2} + (n-2)\right]$$

$$\therefore \quad = \frac{p_c + p_t}{8\,E\,h^2}\left[\,(n-2)\,4\,h^2 - (n+2)\,n\,d^2\right] \qquad (13$$

This is the change in the deflection for a change of one inch in the height of the truss.

Putting this quantity equal to zero, and solving for h, we find the height of truss which will give a minimum deflection to be

$$h^2 = \frac{n+2}{n-2}\cdot\frac{n\,d^2}{4}$$

$$\text{or } h^2 = \frac{d}{2}\sqrt{\frac{n+2}{n-2}\cdot n} \qquad (14)$$

for a minimum deflection.

From Eq. (14) we may find that for a minimum deflection, or for a maximum stiffness, for given working unit stresses, the height of this stiffest truss has the following values:

TABLE OF HEIGHT OF PRATT TRUSSES OF MAXIMUM STIFFNESS.

Height = ...	$1.73d$	$1.73d$	$1.82d$	$1.94d$	$2.05d$	$2.16d$	$2.27d$	$2.37d$	$2.42d$
No. of Panels = ...	4	6	8	10	12	14	16	18	20
$\frac{\text{Length}}{\text{Height}}$	2.3	3.4	4.3	5.3	5.9	6.7	7.1	7.7	8.3

Or we may say that for maximum stiffness for a given amount of material the height of the truss should vary between $1\frac{3}{4}$ and $2\frac{1}{2}$ times the panel length and from 0.43 to 0.12 of the length of the span, as the number of panels varies from 4 to 20. These heights being very nearly those used in the present practice of bridge designing there is no new moral to be pointed from this conclusion.

From Eq. (14) it may be seen that for $n = 2$, $h = \infty$. But by consulting the figure it will be seen the design is not adapted to a truss of two panels.

The objection to any general formula for deflection of any form of truss is that it necessarily involves taking average values for the tensile and compressive stresses, p_t and p_c. These can, of course, only be taken approximately, but if such averages be once computed for a few spans of different lengths, they would probably be found to be nearly constant for given maximum working stresses. Besides the assumed working loads are

seldom or never the actual loads, and hence this new assumption of average working unit stresses is probably as justifiable as the other assumptions that must be made to solve at all. It may be remarked, also, that the equation for height giving minimum deflections, for given fibre stresses, (14) is not a function of those assumed stresses. That is, these are the heights of maximum rigidity for *any* unit stresses, so long as their stresses remain constant for varying height.

Inelastic Deflection.

It must also be understood that neither the general equation (5), nor the particular one for a Pratt truss, (9), makes any provision for the inelastic deflection due to any slack at the joints from pin-holes being larger than the pin. Since this slack would be only one-half the difference between diameter of hole and that of the pin at each end of member, probably an average value of 0.02 inch would be about right for every member of a well-constructed bridge. Now this affects the web as well as the chord members, and it is equivalent to lengthening every tension member and shortening every compression member, except those in the top chord, by this amount. The top chord would be considered one member from end to end. The effect of such lengthening or shortening of any member on the deflection is given by the same ratio u, so that the deflection caused by this slack on any member is $0.02\ u$, using the u for that member. In other words the total inelastic deflection from joints would be

$$\text{Inelastic Deflection} = D' = 0.02\ \Sigma\ u. \qquad (15)$$

remembering to take but one u for the top chord, and that one for the end panel. If the top chord is cut at every panel joint and rests on pins, which is seldom or never done, then all the u's must be summed.

For a Pratt truss, of an even number of panels, with top chord provided with riveted cover plates and planed joints, we have:

$$\text{Inelastic Defl.} = D' = 0.02\ \Sigma\ u = \frac{1}{200\ h}\left[(n^2-2\ n+8)\ d + (n-4)\ h + 2\ n\ \sqrt{h^2+d^2}\right] \qquad (16)$$

For the same example of a Pratt truss, taken alone, where $u = 12$, $h = 400$, and $d = 200$, being 200 ft. long, we find the inelastic deflection to be equal to 0.494 inch. For the conditions named, therefore, the total deflection of this truss would be $2.49 + 0.49 = 2.98$ inches, or say 3 inches.

This is, of course, the total deflection due to both dead and live load, when the maximum load is on, or it is the amount by which the bridge should be cambered to bring it horizontal under its maximum working load.

Camber of Bridges.

A bridge is cambered partly for appearance and partly that the top chord joints may come to a square bearing when the maximum load is on. It of course adds nothing to the strength of the bridge.

The camber should equal the total deflection, being the elastic deflection due to the maximum dead and live loads and the inelastic deflection due to lost motion at the joints.

The general formulas for these two kinds of deflections are (5) and (15)

above and for a Pratt truss they are given by equations (9) and (16) re-respectively.

A Whipple, or any double intersection truss with parallel chords, may be considered as two Pratt trusses, which must deflect together, and hence equations (9) and (16) may be applied to them, being careful to take n, and d for one system only. That is n would equal one-half the total number of actual panels and d would equal the length of two panels of the double system.

There is no question but the present practice of allowing the upper chord to spread at top where the sections join, relying on its closing up when the maximum load is on, is a very poor one. If the cover plates are thin and the number of rivets few, then these joints do actually open and close at top for every passing train. If heavy covered plates on both top and sides and a sufficient number of rivets were used then, as this joint was riveted up, so it would remain. In this case it ought to be riveted up in a horizontal position, and then cambered up to its final position by bending it as a whole from end to end. This could readily be done if this chord were riveted up before the bridge was swung. It would have to be laid horizontally and all pins inserted except one at bottom. After riveting up the top chord the truss could be jacked up and the last joint closed. The upper chord would then bend bodily from end to end and there would be no movement of the splice. One can see that the upper chord of a 200 ft. span would readily bend 3 inches if this bending is continuous, without serious damage, whereas, if it had all to occur at say five or six joints, it would be a source of weakness.

In case the ends of the channels should be cut square so as to come to a full bearing for the maximum load, but riveted up with the camber in, then for all ordinary loads the stress is all thrown on the bottom flanges of the chord channels. It may be asserted that no serious damage would result, but it is at best a very unskillful and botchy way of carrying this stress across the spliced section.

Errors caused by Neglecting Deflections due to Web Distortions.

In all computations of metallic structures based on the deflections, or distortions, of the structure from internal stresses, the ordinary formulæ give erroneous results.

Thus in computing the stresses in a continuous girder caused by the settlement of its supports, or the temperature stresses in an arch between fixed abutments, or the stresses in a stiffening truss of a suspension bridge, the stresses are in all these cases functions of certain assumed or computed distortions. These distortions are always assumed to result in certain bending moments only, and to be wholly provided for by the stresses in the chords. No assistance in accomodating this distortion is credited to the web members. By whatever proportion this distortion is absorbed in the web members the stresses in the chord members would be reduced below those now computed for them.

In the case of metallic arches, and stiffening trusses on suspension bridges the distortion absorbed by the web is small because the trusses are shallow as compared to their length.

I have computed the relative absorption of the horizontal distortion of the St. Louis arches due to a change of temperature, and find that only about one-sixth of it goes into the web. In the computations it was all assumed to go into the chords, or tubes.

In the case of a continuous girder, however, the depth would be great in proportion to the span, and here the computations of stresses due to a settlement of supports, (not supports out of level as usually stated, for if the bridge be built to rest on such supports the formulæ apply,) should take account of the deflection which may be attributed to the web system. Otherwise the computed stresses in the chords, for this case, would be about twice their actual amount.

ASSOCIATION OF ENGINEERING SOCIETIES.

PROCEEDINGS.

BOSTON SOCIETY OF CIVIL ENGINEERS.

APRIL 2, 1890.—A special meeting of the Society was held at the American House, Hanover street, Boston, at 19:50 o'clock. Vice-President Freeman in the chair. Thirty-nine members and seven visitors present.

Mr. James A. Tilden read a paper entitled: "Transit in London, Rapid and Otherwise." A discussion followed upon the methods of rapid transit in London, Paris and Berlin, and upon the system best suited to Boston, in which the following members took part. Messrs. Cutter, FitzGerald, Freeman, Manley, Parker, Tilden and Woods.

Adjourned. S. E. TINKHAM, Secretary.

APRIL 16, 1890.—A regular meeting was held at the American House, Boston, at 19:45 o'clock, Vice President Freeman in the chair. Forty members and five visitors present.

The records of the annual meeting and of the special meeting of April 2, were read and approved.

Messrs. Joseph P. Frizell, Eugene Griffin, and Isaac Rich were elected to membership.

The Secretary read a letter from President Herschel, accepting the position to which he had been elected.

Mr. Tilden, for the Committee on Common Headquarters for Scientific Societies, submitted its report which had been printed and circulated among the members in accordance with a vote of the Society. A very full discussion followed upon the question of procuring a club house, and it seemed to be the unanimous opinion that permanent and more convenient rooms should be procured as speedily as possible. On motion of Prof. Swain it was voted to continuethe committee and that the Treasurer of the Society be added to the membership. The following resolution submitted by Prof. Swain was then passed:

Resolved, That the Committee on Common Headquarters be requested to further investigate the subject of permanent quarters for the Society, to confer with officers of other Societies, and to proceed as rapidly as possible to formulate a definite plan for securing such quarters, and they shall report progress to the Society as often as they deem desirable.

Mr. McClintock presented the report of the Committee on National Public Works. On motion of Mr. Adams the report was accepted and the committee continued.

Mr. Cheney presented the report of the committee on Highway Bridges. On motion of Prof. Allen the report was accepted and the committee continued.

Mr. Howe presented the report of the Committee on Excursions. The report was accepted and the Board of Government was requested to appoint the Committee on Excursions for the ensuing year.

The report of the Committee on the Library was read and accepted, and that committee was continued.

Mr. Swan presented the report of the Committee on Weights and Measures. The report was accepted and the committee continued.

The committee on New State Map was continued till the next meeting.

Mr. Brooks presented the report of the committee to confer with the American Society of Civil Engineer's committee on revision of the constitution. The report was accepted and the committee continued. It was also voted to print and distribute the Committee's report, and to assign its discussion to the next meeting.

Prof. S. H. Woodbridge of the Massachusetts Institute of Technology was introduced and described very fully the system of heating and ventilating which had been placed in the New Engineering Building of the Institute.

Adjourned. S. E. TINKHAM, Secretary.

REPORT OF THE COMMITTEE ON NATIONAL PUBLIC WORKS.

To the Boston Society of Civil Engineers:

After a long and careful study of the river and harbor work, as carried on at the present time, one cannot fail to notice some serious defects in the details of organization and expenditures.

The corps of United States Engineers was first established by an act of Congress in 1794, and an act of 1802 places the officers under orders of the President, and also places under their charge the military academy at West Point.

Since that time we find the engineer corps not only instructing in the art of engineering, but actually at work making surveys and studies, and carrying out some of the most important work of the country, such as canals, railroads, light-houses, military roads, sea-walls and the various kinds of hydrographic work.

There has been expended under the direction of this corps about $200,000,000 and we fail to find one instance of an United States engineer untrue to his trust. The high sense of honor created in the individual members of the corps by the special training and complete freedom from political influence, together with the sense that they belong to so honorable a corps, removes all desire of dishonesty.

The various works on engineering subjects by such men as Humphries, Abbot, Mahan, Gilmore, Weitzel, Newton, Cramb and Mills are strong proofs that the United States engineers are alive to progress and keep well up to the times.

A. D. Bache, in his complete reorganization of the Coast Survey, showed the value of his education at West Point and his experience in the field. Some of the finest docks and canal work have been done under United States engineers, while the Hell Gate mine and deepening of channel we all know of.

It is our opinion that the United States engineers have been, and are now handicapped by eccentric appropriations from Congress, that add to the cost of works by failing to allow them to be carried to completion at once.

If there is a way to remedy this defect it should surely be applied. The suggested specific is that Congress shall appropriate at the start a sufficient sum to complete a proposed work: not necessarily a lump sum, as that would not be practicable, but a total amount in annual payments.

In our minds, this would be an advance that would save enormous wastes, but we are met right on the threshold by doubt whether one Congress is bound by the acts of its predecessor as to making appropriations. If this Congress says yes, and the next one says no, we can easily see the result. If there is an army, there must be an engineer corps. If there is a war, there must be an army.

An engineer corps without experience would be of very little value, while it would be impracticable to hold an organization of this character together without giving the officers something to do, and we know of no better occupation than is that which they now have.

The rotation from place to place is an undoubted injury to the particular work on which the engineer may be engaged, although it acquaints all the officers with the differents parts of the country, which is of immense value in time of war, and may save a hundred times the present loss.

The present arrangement of employing civil engineers is not planned to give the best talent. As far as tenure of office is concerned, that seems to depend on the appropriation; and with the present system, or rather want of system, of giving money for such works, there cannot be many attractions for any engineer of experience or skill. In this respect the government is the loser, and there should be a change.

The government should in some way be able to command the best the country

affords, and should hold out proper positions and compensations to secure them.

The question of a civil pension list seems to be contrary to our free institutions, and should not be introduced without careful study and mature deliberation.

At the first glance the same reasons do not hold to the civil as to the military officer. If we examine more closely, we will find that the United States civil engineer is for the most part employed on a class of work almost entirely performed by government, and his experience is not of a kind to help him in private practice. After devoting years to this work, there would seem to be no good chance for him to start out for himself, while the small salaries in the service do not tend to make him independent.

While we see defects in the present system, we are not so clear as to the best methods of applying the remedy.

Whatever we do should be done without selfish motives and for the best interests of the government, the United States engineer corps, and the great army of civil engineers.

We must work in harmony with the United States engineers in order to accomplish any great results.

This must not be a political move in any sense of the word.

In conclusion, we feel impelled to recommend that whatever action we take, shall be in the form of a memorial, asking for the appointment of a commission to consist of, say, two United States engineers, two civil engineers, two merchants and one lawyer; said commission to examine into the whole subject ot National Public Works, and work out some scheme whereby the much-needed improvements may be effected. Without some such commission, the whole subject is liable to be confused and possibly illegal. The civil engineers will be accused of selfish motives in advocating, while the United States engineers will be charged with the same in opposing, any change, and between the two, nothing will be done.

Respectfully submitted,

W. E. McClintock,
L. Frederick Rice,
Sidney Smith,
Committee.

REPORT OF COMMITTEE ON HIGHWAY BRIDGES.

Boston, April 16, 1890.

To the Boston Society of Civil Engineers:

The committee appointed to consider and report what legislative or other action for the improvement of highway bridges would be advisable, respectfully report as follows:

Your committee cannot recommend any one of the projects which have thus far been proposed for insuring the safety of existing highway bridges and for improving the character of those yet to be built. None of these projects appear to be free from serious objections, and it is believed that some of them might lead to abuses greater than those that are said to exist at present.

Your committee believe that our Society should take a conservative view of the subject under consideration, and use its influence against hasty and radical movements until more definite evidence can be obtained as to the nature and extent of the danger existing in this state under present practices, and the injury to the public and the engineering profession resulting therefrom.

They believe that the tendency of legislation should be toward fixing the responsibility for the maintenance, design and construction of highway bridges, and toward the free dissemination, among engineers and the public, of information relating to the status and condition of these structures.

To this end they favor a law requiring all parties responsible for the maintenance of highway bridges, to have these bridges examined periodically by a competent engineer, in each case, the reports of these examinations, together with the descriptions, plans, and, if considered desirable, photographs of the structures filed with the proper authorities, and made readily accessible to the public.

These reports might also be filed at the State House, in charge of a suitable custodian, or printed in the form of a public document.

After the first examinations and reports provided for in the proposed law had been made, your committee would recommend that the committee on roads and bridges of the legislature, appoint a temporary commission of experts to examine and report upon the evidence thus accumulated, with authority to make further examinations of bridges when their character and conditions are not fully established by the reports at hand.

This commission should report fully and in detail to the said committee and recommend such measures as might seem advisable for securing the proper maintenance and building of highway bridges in this state.

Respectfully submitted,
JOHN E. CHENEY,
D. H. ANDREWS,
EDWARD S. SHAW.

REPORT OF COMMITTEE ON EXCURSIONS.

BOSTON, March 19, 1890.

To the Boston Society of Civil Engineers:

During the past year there have been ten excursions of the Society, including the annual excursion.

The local excursions have been as follows:

DATE.	PLACE VISITED.	NUMBER PRESENT.
May 15, 1889	Sudbury River Conduit and Chestnut Hill Pumping Station	50
June 19, 1889	State Board of Health Filtration Experiments at Lawrence	39
Oct. 16, 1889	Boston Waterworks Sewage Precipitation Works at Winchester	34
Oct. 30, 1889	Hydraulic Excavator of the Mass. Dredging Co.	43
Nov. 20, 1889	Newton Tunnel Sudbury River Conduit	28
Dec. 4, 1889	U. S. Squadron of Evolution (Members accompanied by ladies.)	107
Dec. 18, 1889	Chelsea	30
Jan. 15, 1890	New York & New England R. R. Shops	21
Feb. 19, 1890	West End Street R. R. Electric Power Station	30
	Average attendance	42

The annual excursion took place on Sept. 24 to 27, 1889. Members, with ladies, the whole party being 43 in number, left Boston via the Fitchburg Railroad and spent three days in visiting Rutland and Burlington, Vt., sailing through Lake Champlain and Lake George, down the Hudson river to New York, arriving in Boston via the Fall River Line on the morning of Sept. 27. The excursion was much enjoyed by those present; and we regret that so few members availed themselves of the opportunity.

The committee feels warranted in renewing the claims made in previous years that these excursions have been a great help to bring the Society to its present condition of prosperity and it trusts that they will be continued.

In conclusion, the committee wish to express their indebtedness to members of the Society, and especially to our President and Secretary for valuable assistance in arranging for the excursions.

For the Committee,
E. W. HOWE, Chairman.

REPORT OF THE COMMITTEE ON LIBRARY.

To the Boston Society of Civil Engineers:

During the year the library has had very hard usage on account of the change of quarters. Early in the year the library had to be removed from the Albany Railroad Station and as no new quarters had been provided the books were placed in storage with the other property.

As soon as arrangements were made for the use of room 70 at the American House, the library was moved there and the committee with the assistance of the secretary has spent considerable time arranging it, but it still requires a large amount of work to place it in as good a condition as it was at the Albany Railroad Station.

There has been about 65 accessions during the year including the magazines and society transactions received by purchase or exchange: most of the other accessions are public documents and reports.

The Society is indebted to Mr. Edward Appleton, formerly railroad commissioner, for a contribution of about 20 volumes of early Mass. Railroad Commissioners' Report, and a few reports of other states.

The amount of shelving at present is too small to allow a proper arrangement of the library and there is no room for enlargement and barely room for a member to get at the volumes he may wish to consult.

The arrangement by which the Society's magazines are circulated among those members who have requested it, has worked with varying degrees of success; some members forwarding them within a reasonable time and others neglecting to do so, in some cases holding them for as long a time as ten months and most of them are only returned to the library after repeated notices and many numbers are lost or so badly used as to be unfit for binding, thus entailing additional expense upon the Society to replace them.

The framed pictures and other small articles are stowed in the room with the library and taken care of as well as space will allow, but at present cannot be of any use.

Respectfully submitted,

FRANK W. HODGDON, Librarian,
Chairman of Committee.

BOSTON, March 19, 1890.

MONTANA SOCIETY OF CIVIL ENGINEERS.

MARCH 15, 1890.—Regular monthly meeting. Meeting called to order at 8:30 p. m., Vice-President Herron in the chair. Seven members and two visitors present.

Minutes of last meeting read and approved.

Mr. Danse proposed the following amendment to the By-laws: That Art. IV., Sec. 3 of the By-laws be amended to read, "Five negative votes shall debar the candidate from admission," instead of "An affirmative vote of three-fourths of the vote cast shall be necessary for election." Seconded by Mr. Sizer, discussed and carried.

Mr. Danse moved that letter ballots for new members be so printed that separate names can be detached, so as to prevent the necessity for voting on names of persons unfamiliar to voter. Seconded by Mr. Hovey, discussed and lost.

Mr. Kenna moved amendment to Art. IV. of By-laws be reconsidered. Seconded by Mr. Foss and motion carried.

Mr. Danse moved the substitution of the following amendment for the one reconsidered, and that the Secretary be directed to send out letter ballots on the motion: That Sec. 3 of Art IV. of the By-laws be amended by striking out in said section after the word ballot in the fourth line the words, "An affirmative vote of three-fourths of the votes cast shall be necessary for election," and inserting in lieu thereof the words, "Five negative votes shall debar the candidate from admission."

Mr. Keerl moved that the motion be so amended as to require the Secretary to add to the letter ballot a digest of the discussion on the motion. Amendment to motion accepted. Original motion being put, remarks were called for.

Mr. Keerl stated that he feared the adoption of the amendment might prove dangerous to the welfare and progress of the Society, giving an opportunity to those disposed of exerting a "one man power" influence. He requested that the members observe the full force of the object of the Society as expressed in the Constitution, "The advancement of the science of engineering and the interests of the profession," for while he recognized that personally an applicant for membership might be unpopular, yet he might possess qualifications of the highest order, fitting him to assist materially, through his knowledge and experience, the advancement of our profession and the interests of our Society. Even were we associated alone for the

cultivation of social intercourse he would consider it doubtful policy to exclude one from membership due to five negative votes, for the reason that four of such votes in many cases owe their birth to the influence of one member who has some personal revenge to gratify against the applicant, and that, while he was pleased by the reflection that one of the objects of our association is to promote social intercourse among its members, he regarded such object as of small moment when compared to the initial one—"the advancement of the science of engineering"—and was inclined to look with a want of favor upon any move that would make it possible for one member, through a combination of five friends or associates, to exclude an applicant who, professionally, might be our peer, yet, personally, objectionable to so few. The U. S. Congress reserves to itself alone the high prerogative of judging of the qualifications of its members, as do all other high legislative bodies, and this Society—representative of a profession—should consider itself better equipped to judge of the qualifications of its members than five of the whole number, who would have the power if this proposed amendment is adopted to over-ride through minority control of the sense of the large majority.

He considered that a full and sufficient safeguard had been placed by our By-laws upon the possibility of engrafting upon our membership those unworthy of the honor by requiring three-fourths of the votes cast to be in the affirmative, and was of the opinion that any further reduction of the voice of the majority would be in the centre channel of retrogression.

He further characterized the amendment as wrong in principle and urged its rejection because it places a control of the Society in the hands of a *fixed* small minority, and not as it should be, in a *proportion* of the entire number, for if five control in a membership of 50, they should not, in justice, if the membership should increase to 500.

Mr. Danse expressed appreciation for the motive which led Mr. Keerl to oppose the amendment, but felt that the gentleman took an entirely erroneous view of the situation.

He said that under the present regime the Society was nearer one-man power than under the proposed one. It was a notorious fact that at present three men could bring in any candidate simply by indorsing his application, as was demonstrated by the fact that no application has ever yet been refused.

He expressed a high regard for the Society and its membership, but felt positive that some had been admitted who should not have been accepted, simply because under the present system it was impossible to shut them out. As to the Society becoming a power, he hoped it would, but believed that one good member was worth a hundred hoodlums; not that there was danger of hoodlums applying, but as an extreme illustration of a general principle.

Mr. Hovey favored amendment because he believed the Society should not take in members who were known to five, or even three members, to be unfit or unsuitable for membership.

Mr. Foss stated that he knew positively that some objectionable candidates had secured affirmative votes simply on account of the feeling that under the present By-laws it would be useless to vote against them.

He instanced one case where numerous expressions of regret had been made after the member became well known, and stated that if the voters had known him as well before voting as after he would have been rejected even under the present defective system.

Mr. Sizer stated that he had for some time felt that there was danger of reducing the standing of the Society by the facility with which objectionable and unqualified candidates could obtain membership, and he would certainly vote in favor of the amendment. Question called and motion carried.

Mr. Keerl moved that the Secretary be authorized to employ a competent stenographer to report all meetings and render such clerical assistance as might be needed at a sum not exceeding $5 per month. Carried.

Mr. Keerl moved that the Secretary be instructed to send a copy of the printed pamphlet containing the "Letter of the Committee on Public Surveys to the Hon. T. H. Carter" to each of the Surveyor Generals and to the Secretaries of the Engineers' Clubs and members of Congress from the Western States interested; and that the balance of the edition, with the exception of ten copies, be forwarded to Hon.

T. H. Carter at Washington. Also, that the Secretary request the Secretaries of the other Engineers' Clubs to ask the co-operation of their associations in obtaining the necessary reforms. Carried. L. O. DANSE, Secretary Pro Tem.

WESTERN SOCIETY OF ENGINEERS.

APRIL 2, 1890. 268th Meeting.—The 268th regular meeting of the Society was held at its rooms, Wednesday evening, April 2, 1890, at 8 o'clock p. m., President L. E. Cooley in the chair, with some seventy members and visitors present.

The minutes of the preceding meeting were read and approved, as well as the report of the Board of Directors. At this meeting no business of importance was transacted, except the election of the following gentlemen to membership:

Curtis Dougherty, Charles H. Wightman, Geo. C. Wheelock, C. D. Hill, Fredrick S. Brown, Egerton Adams, William Lee, Charles F. Brown, C. McLennan, H. G. Taylor.

The following were also presented as candidates for membership:

Dwight H. Perkins, Geo. F. Wightman, Edward W. Dewey, John M. Ewen, Ralph M. Shankland, Walker Miller, Frank G. Ewald, Charles Hansel.

A communication was read by the Secretary from Mr. O. Chanute regarding the coming visit of the "Iron and Steel Institute," of England to this country. The Board of Directors had, however, ordered the Secretary to correspond further upon this subject, before submitting it to the Society for action.

Before taking up the topic of the evening, the President announced that, in connection with the World's Fair in which all were interested, Mr. Jenison, the Chicago architect, was present with plans of his novel project for a building, and he would call upon Mr. Jenison to give the Society a brief description of the scheme.

Mr. Jenison spoke as follows:

The idea is to build a round building, 3,000 feet in diameter, like a tent, with a centre pole. The thought has been, wherever it may be located to build an outer wall, 60 feet high, on which to build two galleries 75 feet wide each, and the entrance will be on the first gallery—for two purposes: One, that we might have an opportunity, at the first entrance of the building, to get all of the effect that the entire building could give; the other, that we might have an opportunity to have uninterrupted railway tracks around the entire perimeter. The third gallery, is, in our mind to be given over entirely to the stock people, giving them a race track one mile and three-quarters long. The idea of classification was to arrange the exhibits with subjects on the perimeters, and nations on the radial lines, fixing it so that one could find a certain subject discussed and shown without searching among the entire exhibits, and by following the one line, could catch it all; if they wanted to study a nation, follow it on the radial line.

This classification would bring about naturally, if located where it was possible, a space for marine exhibits, giving a canal 150 feet wide. Toward the centre would be an amphitheatre 600 feet in diameter. In other words, larger than the Colosseum at Rome. In the centre would be a pole rising to the height of 1,000 feet, from which would be pendent the wires to the outer wall. I say wires, because although we have discussed different methods of construction, this seems to be a favorite one on account of its simplicity. In case of wires, and if they were No. 7 wires, it would take 282,000 of them. They would go to the outer wall, making a netting that one could walk over. Our idea was to leave every sixth of these wires so slack that we could use them as lacers, on which we could lace our purlins. It has been proposed that aluminum be used for the roof. It would add to the expense, but decrease the weight some, and make a brilliant roof.

The purposes that we believe this would accomplish are first, it would certainly be a novel idea. Next, it would accommodate the necessities of our exposition on this occasion, for there is no doubt in my mind, and won't be a doubt in any one's mind who studies expositions, and finds what has been done, that we have got to have 160 acres of floor space. At Philadelphia they had 60. At Paris, 73. In the Paris Exposition, the railway exhibit was like one of our freight yards, and one had to crawl under cars, and around in order to see it. We have satisfied ourselves that to get that area in isolated buildings of such a class, as is almost a necessity, will cost about fifteen millions of dollars, and we find here that we can enclose, floor, roof over, and complete ready for occupancy, this building for less than six millions of dollars. From a financial standpoint it seems to be a success.

It has been said that for us to build another Eiffel Tower would be vulgar, but if we build a tower that is a necessity, an integral part of our construction, it ceases to be vulgar—it is a practical fact. Let me say that it was our idea that it was impossible to have any such building that would be of any earthly use after this exposition was over. Hence, any construction that would bring about the largest amount of returnable material would be that much real gain. We would construct the centre pole entirely of railway rails. Of course I know that it has been a settled fact among engineers that a construction of railway rails was not an economical one, but that has been in the light of a permanent construction. If a plan can be pursued that will bring those rails to the ground again in merchantable shape the argument will fall to the ground The reason for abandoning cable and using wires was that wires at that length are merchantable to their full value or nearly so.

In reply to numerous questions Mr. Jenison gave additional views:

In that centre pole, we had thought, and we believe yet, that the best scheme of construction would be to start a pole thirty feet in diameter on a foundation that was not intended to hold it and build it, guying the pole in the open, and let it settle—it will stop somewhere, and make the same provision for taking care of the roof that we do in the tent. Another idea was to go to rock, and start there on the square and build. We have discussed it from thirty to sixty-six feet in diameter of various sizes, and do not feel prepared yet to pass judgment on which is the best. Brick walls would be used, with an iron ring around the top of the wall, guyed down with 400 guys.

We would use steel drawn wire of the highest grade—tested to the highest capacity. No. 7 is what we have been figuring on, and it would weigh about 40 million pounds.

For the center the idea was to build a pole that would extend above the top of the tower, some 400 feet, and use it as a guy pole, pushing it along up as we needed it and finally pushing it out. That would be a boiler iron pole.

The cost would be less than six millions of dollars. That is one of the things that has been used very strongly because of the great economy over any other method that could be pursued.

It would be about a half a million less than it would be to put columns in the building and make a level roof. We can figure no other plan of covering it so economically as this. The cost of the Philadelphia exposition was at the rate of $75,000 an acre; this would be at the cost of $37,500 an acre at the estimate of six millions.

As to the multitude of wires obscuring the light they would come tight together around the top, but they would be bunched and you would have a lot of diamond-shaped openings. There are twenty banks of those wires on the top pole, where they take hold of the pole.

It will stand a great deal of vibration without doing it any injury. I don't think the glass would stand a good strong wind without risk of any breakage, and hence take the precaution to put in a netting under the glass so that if the glass is broken it would not come down.

Considerable discussion was held on vibration, but time being valuable the President called for the topic of the evening, "The Chicago Railway Problem, Especially in Relation to Terminals, Rapid Transit and the Avoiding of Accidents at Street Crossings," and briefly introduced the subject.

The Secretary read letters from Mr. Richard Morgan, of Dwight, Ill., Mr, Chanute and Mr. Fred Davis, in which the importance of the matter was acknowledged, but regretting inability to discuss it at present meeting.

The President then called upon Mr. John F. Wallace, who said that in their office they had been making a great many estimates on the different features of the case, but he had not made sufficient progress yet to give out any views whatever. In a general way he would say: That this is a problem that has been brought forward by the peculiar conditions of our country and the peculiar growth of Chicago. The cities and the railroads have grown up together—the cities helping to make the railways, and the railroads helping to make the cities. The railways now come into the hearts of the cities under rights given them at an early date, and they naturally take the ground, that is, the managers with whom I have conversed, that they cannot be compelled to make any improvements in this direction that involves any considerable expense upon their part. The idea of course upon which they operate is this: Revenue and revenue only to their stockholders. The interest that the city takes in it is: Safety to its citizens and inter-communication between the different parts of the city, and the question, not only to life and limb, but also of delay in transacting busines between one part of the city and the other. To the part of the citizens who live in the suburbs it is merely rapid transit. These are the three main interests that seem to be involved, and, of course, without concessions on the part of the city and upon the part of owners and operators of the various industries along the line of the roads, it will be impossible to ever come to any solution of the question. There is no doubt that either an elevated system or an underground system—if it were possible to carry it out—would be the solution of the question, as far as speed in operating the train is concerned, and as far as the safety and the free inter-communication between the different parts of the city, also to avoid delays to street traffic. The main objection to a subway is the low elevation of the city with respect to the lake, and also the difficulty of access to the industries that are situated in the heart of the city. The main objection to the elevated plan is, first, the expense of elevating the lines; and second, the difficulty of access to the various

industries. In the few preliminary estimates the expense of a four-track elevated structure is about $800,000 per mile. That includes retaining walls, filling of embankment between the retaining walls and steel bridges over the various street crossings. That is also based upon head room of 12 feet above the ordinary established city grades of the various streets. Taking up the idea that has been suggested of depressing the street partially and elevating the railways partially, a difference of less than 20 per cent. in favor of the depression of the streets. The small saving that is made by that method of construction is almost counterbalanced by the cost of the depressed streets and their repaving, and the retaining walls that are necessary to keep up these embank ments on the sides of the streets, and also in the expense necessary to take care of the sewerage. The above estimate includes a four-track line. In regard to head room, we are building a viaduct in which we have cut down the distance between the base of the rail and the under side of the iron work to 18 inches. I simply mention that as one of the items that affect head room, or affect the height of any embankment.

An estimate on what it would cost to construct four viaducts across four of the principal streets that the city would require our road to build in the next five years, and also the capitalizatiou of the operating expenses due to the maintenance of watchmen or guards at the various crossings and the mile and a half which the estimate covered, the capitalization of the operating expenses, plus the cost of the viaducts, plus the land damages, etc., make a capitalization of about one and one-third million, on a mile and a half of road. In some cases the continuance of the present system is really the most expensive; that is, if the policy of the city were carried out, to build viaducts over every third or fourth street. But that only takes in main lines. The main difficulty is the access to industries that are now located along the sides of the existing lines. In regard to the expense of any system that might in the future be decided upon between the railroad companies and the city, it seems to me that under the existing condition of things, the railroads and the city having helped each other to arrive at the present condition of things, that no system should be decided upon that the public is not willing to bear its just portion and share the expense. The most of the trunk line railroads that run into Chicago to-day are dividend-paying roads, due more to their terminals in Chicago than to the particular management of their respective lines. They should undoubtedly, owing to the advantages that they have received, through their access into the city, bear a large proportion of the expense of any system that might be adopted. The city, on the other hand, having been partially created by the railroads, and receiving the benefits due to safe and uninterrupted travel, should bear part of their expense, and it seems to me that the city should bear the entire expense of the elevation of the tracks beyond what the capitalization of the operating expenses would be, due to the present system of operation. In regard to the industries in the yards and the handling of the freight, we could have the establishment of transfer yards. These are now contemplated by one railroad company in the town of Lyons. If it met with the support of the other railways entering the city it would remove a large portion of the switching from Chicago: it would relieve the switching done inside of the limits of the city entirely, and leave that part of it due to the city itself. It might be possible by the purchase of cheaper ground, on the outskirts of Chicago, that a great many of our present industries might be induced to move to these localities and the high-priced land they now occupy might be used for other purposes. This subject is so broad and so deep that it will take some time—more time I imagine than any person connected with the Society has to give it—to arrive at any positive conclusions upon the matter. What I have said I do not mean to express really as an opinion, but to give the matter a start before the Society.

There is no question but what in the future this question must be met and must be solved by some different method of terminals, and some different method of operation of the roads than now exists, and that solution will be radically different from what we now have.

There is another question. Most of the railroad men take this view of the question—that they are not required to make any changes; that the city and State Legislature have no authority to make any changes, but if the present system is persisted in, it is possible for the city to make such restrictions, or police regulations that would increase the operating expenses of the railroads, in regard to watching crossings, &c. It might very easily put such a burden on the road that the capitalization of the operating expenses would more than compensate for the increased cost of construction, and would make it pay to make even radical changes.

Mr. Isham Randolph. Two of our leading corporations have given a great deal of thought and labor to this topic, and I had the benefit of their labor. They seemed to have reached the conclusion that so far as they are concerned, elevating tracks is purely practical. That is the horn of the dilemma they prefer taking if they are driven to take any. They have found that they can depress the streets some five feet and raise the tracks to get the needed headway. Of course it is utterly impossible to dispense altogether with grade tracks, unless they go to the immense expense of raising their whole yard system, so it is preferable to keep that elevation as low as possible, in order to reach these yards by an easy descending grade, that would hardly be less though than 1 per cent. So far as reaching industries and freight houses is concerned, I think that difficulty can be overcome. Several years ago, I was associated in the construction of a large freight house. It was a three-story building, and there are five elevators there, and they make continued use of all the floors, unloading of course on the middle floor. They find that is a source of considerable revenue to them to have this immense floorage area, and that same system could be carried out by the other railroads. Here, where land is so costly in the city, it seems almost worthy of the outlay to get the use of the area which lies below the tracks for business purposes.

I would elevate the cars say to the second floor, and have the use of the area below those tracks for storage and other purposes. So far as the coal business is concerned, I think it would be benefitted by the elevation of the tracks.

I think that the elevation of the tracks above the streets would solve the rapid transit problem at once. You could run as fast as you pleased then.

It seems to me that if you make these roads elevated, it would do away with the necessity for any other class of elevated roads.

Mr. Geo. S. Morison. The question is one which I have really never given much attention to in Chicago, but there are one or two little points now which I think something might be brought out on. It is not simply a question of clearing the railways from the streets. It is quite as much a question of clearing the railroads from each other. You can conceive of a condition in this city where you would want a four-story railroad, and a street under it below that. Unfortunately, the tendency has been to require an increased height for railroad crossings. Fifteen years ago, eighteen feet was considered a good deal. Twenty feet was asked a few years later, and now there are a good many railroads that insist they can not operate safely unless there is a clear head room of twenty-one feet above the track, and that has been due to the introduction of special classes of rolling stock, which the different freight managers have put on their roads as attractions against other lines. The furniture cars are fourteen to fifteen high, and they claim that when a car of that kind is put on a railroad, they must have their bridges of such height that a freight brakeman can stand on that car. Couldn't there be some fixed rule for regulating the height of the cars? I think the standard rule within the city limits is only sixteen feet above the rail. Go outside the limits and those same roads are asking for twenty-one. Why would it not be possible, in a few years, if some fixed rule is adopted to bring down that elevation to fourteen feet? If we could once come to that, this question would be very much simplified. I do not know that that bears very directly on this subject, but I think it is a matter that has never been given proper attention.

Mr. Alexander. I have not given this much attention, but my opinion is that the solution of the question in the future will be that the railroads will all be under ground. That in time we will have a complete system of underground roads, with a central depot, and I think that will be the solution of the rapid transit question. I think the drainage of the tunnel will be a very simple matter.

Mr. L. E. Cooley. The general thought which presents itself to me is to look at it first from what you would call the ideal standpoint and then to approach it as nearly as may be practical to do so. That system to-day would shape itself about in this way, in my mind: Suppose we had, at a distance from Chicago, a belt line road, say ten or fifteen miles out, and where all railroads would go to a common yard, as proposed in the Stickney scheme, which would take out of the city absolutely all traffic in the day time, and in the evening would move about the city such as was intended for local manufacturing purposes. That going to some other point would not come into the city at all. It would remove from our interior lines here everything that came in the nature of freight traffic, except that which belongs in our local freight houses in our local manufacturing points, and that to be moved in the night time. Now, in regard to the railroads themselves that would leave them free during the day time for a rapid transit system, and I consider that the distribution of the railroads of this city would give the best rapid transit system that any city on the globe has. We have practically here a level plain, with railroad lines going out like radii from the centre and reaching with facility a distance of twenty miles within half an hour, if the roads were not obstructed. Now, in regard to the treatment of the question within the city itself there are the two general views suggested. I think that everybody agrees that the system of viaducts is the most expensive. The two general views are elevating the tracks or depressing them, and both systems have their advantages and advocates. I think the wiser plan would be, if it were possible to do so in the heart of the city, and for at least four or five miles out, to keep the heavy traffic on the lower story and carry your street traffic above Suppose it were possible to concentrate the different roads which enter the city on certain trunk lines. Give them right-of-way of a certain width, which they can use for their railway purposes and allow them to work out their own salvation inside of that, and to put their tracks down so that streets could cross at city grades. That is the general thought. Now, is it possible in any way to bring about a thing of that kind? Of course such a system as that would accomplish the system of rapid transit of which I first spoke within the space which these lines reach, and with our cable roads, it seems to me might solve the problem. If we could get something of this kind as an ultimate condition, and what we do, do in harmony with this plan, or some other plan which may be decided on as wisest. If you could suppose that all the railroads of this city would form a terminal company, in which they could pool all of their values of investment, inside of this so-called belt road, and have freight houses and tracks and everything of that kind that supply this whole interior area, in common, so that a road when it wanted to get somewhere, does not have to build a line there itself, but all the lines to be used jointly. Then go to work and unravel this enormous evil of grade crossings which we have now all over the city, and bring them in in parallels,—like skeins of silk. We are allowing such troubles as that to grow up all over this city. It seems to me that the railway officials and others interested in the question of transportation, can in some way get together, and create a proper body of men to give this a thorough and comprehensive study, from the ground up. It will cost a good deal of money to do a thing of that kind, but whatever it costs, it is a wise expenditure to incur on the part of somebody, whether it costs $200,000 or $500,000. The point is this, that on the solution of great questions of this kind virtually depends the vitality of our future growth. The question is, if as a community we can go at this work in a systematic way, the same as we would if we were individuals handling the same ques-

tion. We should go at it in a comprehensive way,—not throwing away our money in elaborating expensive schemes that cannot be now carried out, but spending wisely all that is necessary to facilitate and solve this question in harmony with a policy which carries the ultimate solution. A good many people say, we can force the railroads to a solution of this problem if we keep our backs up. If they get a solution of this question in ten years, I shall be very happy, because it is something that involves a large expenditure and a long time before it can be completed. However, you can establish a policy, and whatever you do, do in harmony with that policy. That is my general thought in regard to this subject.

Mr. Guthrie: I look upon this as the time to move. The subject is, however, too big to talk in one evening. I would urge strenuously the appointment of committees to investigate this matter in a thorough and business-like way. We must do here this kind of work. The public are not prepared to do it. I believe that we have got to elevate the roads. We all acknowledge that we have reached a point where either the roads must be depressed or raised. I see so many obstacles in the way of sinking the tracks that I reach the conclusion that they must be raised. I believe that the value of the storage area that would be created by raising the tracks would go a long ways towards defraying the expense. I look at it in this way. Chicago is indebted to the railroads, and the railroads are indebted to Chicago. This change should be a charge, the expense of which should be mutually borne, or borne in such proportion as to equalize the burden and place it where it belongs. I do not believe in trying to pass ordinances to compel the roads to do things they ought not be asked to do. There are many things conspiring to indicate that this is the time. The World's Fair coming to Chicago. The rapid transit question is pressing harder every day. We had a trial of slow transit, and one week answered the purpose. It don't work. I believe there should be committees appointed well adapted to investigate the subject, and dividing it so that the work will not fall heavily on any of them.

The importance of the discussion and the desire for further discussion led to Mr. Wallace proposing that a committee of five be appointed to investigate the matter and make a report to the next meeting. Not to form any conclusions, but simply to systematize the matter, both in regard to railway problems as a whole, and in regard to rapid transit also. To present a report for the purpose of discussion at that time. He also suggested that that committee be requested to have this report ready and submit it to the Secretary for distribution at least a week or ten days before the next meeting of the Society.

The motion was carried and the President appointed Messrs. Wallace, Randolph, Morison, Strobel and Alexander.

Meeting adjourned. JOHN W. WESTON, Secretary.

THE CHICAGO RAILWAY PROBLEM.

Report of Committee.

EXTRACT FROM STENOGRAPHIC REPORT OF APRIL 2 MEETING RELATING TO THE CHICAGO RAILWAY PROBLEM.

PRESIDENT.—I should deem it wise to continue it if the interest in it would continue. If somebody will make a motion we can come to some conclusion.

MR. WALLACE.—I move that a committee of five be appointed to investigate the matter and make a report to the next meeting; not to form any conclusions, but simply to systematize the matter, both in regard to railway problems as a whole and in regard to rapid transit also; to present a report for the purpose of discussion at that time. I would also suggest that that committee be requested to have this report ready and submitted to the Secretary for distribution at least a week or ten days before the next meeting of the Society.

Motion carried.

CHICAGO, April, 14, 1890.

J. W. WESTON, C. E., Secretary,
Western Society of Engineers,
78 La Salle street, City.

DEAR SIR:—I herewith transmit to you a copy of the majority report of the committee to consider the railroad problem. I also attach important papers and

correspondence which may be of interest to you. The probabilities are that Messrs. Morison and Strobel will submit a minority report. Yours truly,

J. F. WALLACE, Chairman.

CHICAGO, April 14, 1890.

WESTERN SOCIETY OF ENGINEERS, CITY:

GENTLEMEN—Your committee to consider the railroad problem of Chicago, Ill., would respectfully make the following report, in which we have followed the instructions given to the committee upon its appointment by the Society at its meeting of April 2d, and in which we have outlined the different plans that have suggested themselves for a solution of the problem, stating the leading advantages of each plan and the principal difficulties in the way of its execution.

Yours respectfully,

J. F. WALLACE,
I. RANDOLPH,
H. C. ALEXANDER.

Your committee suggested that the Chicago Railway Problem be considered as follows:

I. A COMPLETE SYSTEM OF ELEVATED RAILROADS FOR THE CITY OF CHICAGO.

1st. Its advantages to the general public are: It insures safety of life and limb to all persons using streets and alleys of the city at their present grade.

2d. It affords a means of rapid interchange of business and solves the difficulties of suburban passenger travel.

3d. It affords undelayed and uninterrupted street travel.

ITS ADVANTAGES TO THE RAILROADS.

1st. It affords facilities for the rapid and convenient movement of trains; the rapid movement of trains in a crowded locality being the economical movement.

2d. It reduces the time necessarily consumed by through trains.

3d. It reduces the operating expenses by dispensing with the policing of public crossings, and making unnecessary the use of gates and other costly mechanical appliances.

4th. It eliminates the element of damage for personal injury due to persons crossing the railroad streets.

5th. The increased capacity for train movement due to release from the operation of the city ordinances restricting length of trains.

THE DISADVANTAGES OF A COMPLETE ELEVATED SYSTEM.

1st. To the city and the general public using its streets and thoroughfares there can be no objection urged to an elevated system.

2d. To the railroads the disorganization of all the existing methods of exchanging business with industrial works and warehouses, round-houses and shops.

3d. Increased cost of maintenance of an elevated system over a grade system.

II. HEAD OF DISCUSSION, A SYSTEM OF RAILROADS DEPRESSED BELOW THE GRADE OF THE STREET.

1ST. ADVANTAGES TO THE GENERAL PUBLIC.

Its advantages are identical with those set forth under the first head of this discussion, with this further advantage, that the view of all unsightly structures and trains is removed from the public gaze.

2D. THE RAILROADS.

To the railroads the same advantages, as to rapid and uninterrupted movement of trains: abolition of police protection and elimination of the element of damages for personal injuries at crossings are secured by the depressed as by the elevated system.

3D. THE DISADVANTAGES OF A COMPLETE DEPRESSED SYSTEM.

To the general public, the disadvantages lie in the direction of difficult communication with the public carrier system of the country; the communication with warehouses, factories, docks and wharves being attended with great cost, and complicated with the great and unsolved problem of drainage.

4TH. DISADVANTAGES TO THE RAILROADS.

1st. A depressed system is met at once by the difficult problem of drainage. This problem involves the shutting out of seepage from the soil, the grade line being of necessity many feet below the lake level, and hence below the line of saturation. Added to this the difficulty of caring for the surface drainage of so large an area.

2d. The construction difficulties due to the depression of existing tracks and structures while keeping up the movement of trains, and the transaction of business.

3d. The difficulty of disposing of the immense volume of excavated material.

4th. The necessity of raising the entire volume of traffic from the low level of the tracks to the plane of the existing streets.

III. A System of Railroads Partly Elevated and Partly on the Surface.

Under this head the advantages and disadvantages of the system are those of the two systems previously discussed, and the preponderance of merit will depend upon the treatment of each particular case governed by its local conditions. This general statement refers to the 4th head of the discussion as well as to the 3d.

To the city the advantages of a system of railroads partly elevated and partly on the surface, means the removal of the most objectionable features of the entire surface system; by elevating the tracks used for rapid transit and leaving upon the surface those used for connection with industries, freight yards and shops; tracks which are not in constant use, and over which motive power and cars never pass at high rates of speed.

To the suburban citizen it secures the rapid transit which is so essential to the growth and prosperity of suburban towns. To certain classes of citizens of the city it is of advantage, inasmuch as it secures to them the continuance of their present trackage to manufactories, warehouses, etc., without the inconvenience and cost of revision to meet new physical conditions, an advantage which is also shared by the railroads.

To the railroads the advantages are:

1st. It secures to them the undeniable advantage of rapid transit with a minimum outlay and disorganization of existing methods.

2d. It minimizes the cost of policing and protecting mechanically the public highways and streets.

3d. For all through and suburban passenger trains it gives freedom to use high rates of speed without menace to the city inhabitants as far as the elevated system is adopted.

4th. It admits of a gradual treatment of the subject in accordance with the conditions to be met within each particular case. The work could be carried on by sections to meet the requirements of particular localities or the peculiar conditions affecting each individual road. The work could be restricted in its extent to meet the financial ability of the road undertaking it; in fact, the development of such a system would take the form of growth more or less rapid, and not of revolution.

5th. Such a system would admit of the disentanglement of the complicated and dangerous grade crossings now existing within the city, by passing one road or system of roads over another road or system at a sufficient elevation to make it safe for the road upon the lower level to operate its tracks. This would eliminate dangers to the life and property of the traveling public which are as real and terrible as the dangers of the surface system can possibly be to those using streets and highways crossing railroad tracks.

6th. This ability to abolish the railroad grade crossing would remove a constant element of delay and of expense. Watchmen could be dispensed with at such crossings, and the outlay for costly and complicated interlocking devices which must be made if grade crossings are continued would be entirely avoided.

OBJECTIONS.

This system will diminish the objections urged against a grade system, but as being only a partial solution of the problem, it is to that extent objectionable. It is objectionable inasmuch as it is proposed to maintain certain tracks upon the surface to be used for switching purposes, and the danger of these tracks lies in the obstructed view when approaching from the side of the elevated tracks away from the surface tracks. Persons are liable to come upon these surface tracks and be run down by moving cars or engines which could not have been seen as they approached the crossing.

CHICAGO, April 7, 1890.

PRELIMINARY REPORT OF SUB-COMMITTEE TO THE COMMITTEE APPOINTED TO CONSIDER THE RAILROAD PROBLEM OF CHICAGO.

GENTLEMEN—Your Sub-Committee have considered the subject matter under consideration only partially, and transmit to you herewith a preliminary draft of their report. You will please look over the report and communicate at once to Mr. I. Randolph, at room 42, Rock Island Depot Building, your views in regard to the attached report, and make such suggestions as you see fit in regard to either the report or the subject matter in general. Please give this matter your immediate personal attention, as your Sub-Committee wishes to revise and enlarge upon this report at an early date. Yours truly,

ISHAM RANDOLPH,
J. F. WALLACE,
Sub-Committee.

CHICAGO, April 9, 1890.

MESSRS. ISHAM RANDOLPH AND J. F. WALLACE, Sub-Committee.

GENTLEMEN—Your preliminary report of the 7th reached me yesterday afternoon. I have examined it and it seems to me that the report hardly goes in the right direction. It gives in a general way the supposed advantages and disadvantages of certain systems of obviating existing grade crossings and that is all. It pays little attention to the physical side of the question and consists principally of generalities. It fails to consider at all what seems to me as important a question as any, and that is grade crossings of railroads with each other.

It seems to me that the report of our committee should be very concise, it should outline some physical facts and make recommendations which will be open for discussion and revision. Following this outline I have prepared the draft of a report which I submit as a substitute for the one sent me. Yours truly,

GEO. S. MORISON.

CHICAGO, April 14, 1890.

GEO. S. MORISON, ESQ., Room 1,120 Rookery Building, City.

DEAR SIR:—Your letter of April 9th, handed us by Mr. Strobel, at hand, also the amended draft for a proposed report of the Committee appointed by the Western Society of Engineers to consider the Railroad Problem of Chicago.

We think that you misunderstand the intention of the Society in the appointment of our Committee. We constructed it to mean that our Committee should formulate a plan *for* discussion and not a plan *to* discuss. In other words, we consider the meaning of the Society to be that we should simply present the matter in a general form in order that the Society might discuss different plans, and that the meaning of the Society was not that we should submit a definite plan to discuss. Mr. Alexander and ourselves have agreed to send in a report as per the draft submitted to you and Mr. Strobel, and we think it best, owing to the radical difference

between the views intended by Mr. Strobel and yourself and those intended by us that there should be both a minority and a majority report.

If you and Mr. Strobel will endorse the draft of report submitted by you to us and return it to Mr. Wallace, he will submit the matter as a minority report.

Yours truly,
J. F. WALLACE,
I. RANDOLPH.

CHICAGO, April 16, 1890.

J. W. WESTON, C. E., Secretary Western Society of Engineers.

DEAR SIR:—I transmit to you herewith a minority report from the Committee appointed to consider the Railroad Problem. The difference of opinion existing between the members of the Committee was not so much as to the merits of any particular plan, but as to what was the proper province of the Committee, the majority holding that the Committee should simply formulate the different plans suggested, stating their advantages and disadvantages. Yours truly,

J. F. WALLACE, Chairman of Committee.

CHICAGO, April 15, 1890.

J. F. WALLACE, ESQ., Chairman of Committee, Home Insurance Building, Chicago, Ill.

DEAR SIR:—Enclosed I hand you the proposed report of the Committee to consider the Railroad Problem of Chicago, signed by Mr. Morison and myself. We agree to your proposition to submit this as a minority report. Yours truly,

C. L. STROBEL.

MINORITY REPORT.

PROPOSED REPORT OF COMMITTEE APPOINTED BY WESTERN SOCIETY OF ENGINEERS TO CONSIDER THE RAILROAD PROBLEM OF CHICAGO.

REQUIREMENTS.

The one requirement of the Chicago Railroad Problem is understood to be the avoidance of grade crossings and the dangers attending the same. The grade crossings are of two kinds: the crossings of streets by railroads, and the crossing of railroads by each other: any plan which fails to cure both classes of crossings is not worthy of consideration.

GEOGRAPHICAL EXTENT.

Any plan adopted must provide for the abolition of grade crossings at least within the entire limits of Chicago; but it is not necessary that the work should all be done at once, and a plan which provides for the removal of grade crossings within a radius of four miles from the intersection of State and Madison streets and is susceptible of extension, will meet the required conditions.

GENERAL PLANS.

Three general plans may be considered:

1st. The elevation of all railroads.
2d. The depression of all railroads.
3d. A combination of elevated, depressed and surface railroads.

ELEVATION OF TRACKS.

The elevation of all railroad tracks would solve the problem of grade crossings of streets, but it would not solve the problem of crossings of railroads with each other unless some of the tracks were elevated at least twice as much as others; would interfere very seriously with all existing freight facilities; for these reasons this plan is not recommended.

DEPRESSED TRACK.

The system of depressing all tracks presents the difficulties above named for elevating tracks, besides which it would involve some very difficult questions about drainage, and would be disagreeable for passenger service. For these reasons this plan is not recommended.

COMBINATION ELEVATED, DEPRESSED AND SURFACE TRACKS.

This last plan seems to be the only one which offers any chance of avoiding the grade crossings of railroads with each other, as well as street crossings, at no unreasonable cost; it is, therefore, in a general way, the plan which your Committee recommend.

In determining what tracks should be raised, what depressed, and what kept at their present elevation, the following considerations should govern: The preference should be given to elevated tracks, no tracks being retained on surface except where this becomes necessary to connect with existing yards and industries and to avoid grade crossings with the elevated lines; wherever tracks are retained on the surface, the streets should be carried over them on viaducts, the number of viaducts varying from every street to every third street, as may be determined by traffic; the depression of tracks should be resorted to to only as an extreme measure.

A clear head room of 16 feet should be the maximum required over railroad-tracks and a clear head room of 12 feet should generally be accepted as enough over streets.

The grades to be used in the approaches to street viaducts should vary from 2.5 to 6 per cent. according to the class of traffic. The grades to be used on railroad lines should vary from 0.5 to 2 per cent., the former to be used generally on all main lines, and the latter to be used only in exceptional cases where one road has to be depressed under another.

As a general outline of a plan to be considered, your Committee suggests the following as a solution of the problem within four miles of the intersection of State and Madison streets. The tracks of the Illinois Central Railroad are along the lake and the tracks of the different railroads which follow close to the Chicago river (which are already generally crossed by viaducts) with their connecting yards should be retained at present elevation. The two principal east and west lines being those which follow Sixteenth and Kinzie streets, should be maintained on the present surface and the street carried over them on viaducts, The North and South lines should be elevated; the St. Charles Air Line should be treated specially.

The details of construction may be left to be determined by the management of the different railroads, it being generally understood that iron structures or solid embankment between crossings, with iron bridges over the crossings, would be satisfactory.

This report is respectfully submitted for discussion before the Society.

GEO. S. MORISON,
C. L. STROBEL.

CHICAGO, April 9, 1890.

CIVIL ENGINEERS' CLUB OF CLEVELAND.

APRIL, 8, 1890.—Regular meeting held in Case Library at 8 p. m., President Searles in the chair.

Minutes of previous meeting read and approved.

Mr. Harry Fitch Coleman elected to active membership.

The President made some remarks relative to the present condition of the Club and the need of larger rooms for meeting and library.

Prof. Howe, Chairman of the Programme Committee, reported the calendar of regular meetings for the ensuing year.

Mr. Eisenmann stated that the Cleveland Architectural Club desired to form some affiliation with the Civil Engineers' Club for the joint use of the rooms and

other purposes, and they desired to know if the Club would favor such action. Referred to the Library Committee.

The President announced the receipt of communications from the Committee of the American Societies of Civil Engineers inviting a committee of conference on the question of affiliation with them. A motion was made to refer the matter to a Committee, which, after some discussion, was passed. Committee appointed: Messrs. A. Mordecai, John Whitelaw, William H. Searles, J. F. Holloway, W. R. Warner and H. C. Thompson.

The President reported the receipt of various papers, etc., sent regularly to the Club, and suggested an enquiry be made to ascertain to whom the Club is indebted for them, that the journals of the Club may be sent in return.

Mr. Thompson suggested that a large specimen of building stone formerly owned by the late Mr. Charles Latimer be received by the Club. Motion to that effect made and carried.

Motion by Mr. C. G. Force, Jr., that a committee consisting of J. F. Whitelaw, W. P. Rice and S. J. Baker be appointed to prepare and present a memoir of the late Mr. James S. Oviatt. Carried.

Motion by Mr. Hermann that a committee be appointed to carry out the suggestions of the President in regard to procuring larger quarters. Carried. And the President appointed the following committee: Messrs. W. R. Warner, S. T. Wellman, Wm. Chisholm, H. M. Claflin and James Barnett.

A carefully prepared paper was then read by Mr. Ambrose Swasey entitled, "The Eiffel Tower from Foundation to Lantern." It was illustrated by a number of large diagrams of the foundations, elevators, etc. The discussion which followed was taken part in by President Searles and others.

Mr. Whitney, of the Pratt & Whitney Company, of Hartford, Conn., was present and extended an invitation to any of the members to visit their works at any time.

Club adjourned. C. O. PALMER, Secretary.

ENGINEERS' CLUB OF ST. LOUIS.

[illegible]26TH MEETING, APRIL 1[illegible], 1890.—The club met at 8:15 p. m. at the rooms of the Elks' Club, President Nipher in the chair; twenty-seven members and two visitors present. The minutes of the [illegible]25th meeting were read and approved as corrected. The executive committee reported the doings of its meeting of same date. Mr. Robert Moore, chairman of the committee on conference with the American Society of Civil Engineers, regarding proposed affiliation with that society, submitted a report for the committee. After discussion, in which Messrs. Blaisdell, Prof. Johnson and others took part, it was, on motion, ordered that the consideration of this report be made the special order for the next meeting, the Secretary in the meantime to send copies of the report to all members.

Mr. Isaac A. Smith then read a paper on "Railway Inclines." He described fully the uses of these devices and gave his experience in their construction and operation. He made certain suggestions in regard to proposed improvements which would increase their efficiency. He also gave figures on the cost of inclines, and that of the necessary steamers, locomotives and crews to operate them. He stated that an incline, embodying the improvements suggested, was now in process of construction at the foot of Mound street in this city. The discussion was participated in by Messrs. Robert Moore, Russell and Ferguson.

The Secretary then read Mr. Arthur J. Frith's paper on "Some Practical and Theoretical Constitutions of the Screw as an Element of Mechanism." The author stated that the proper design of the screw depended upon the uses to which it was to be put, and he considered the question under a number of different heads. He called particular attention to the importance of having the co-efficient of friction as

small as possible. He also devoted special attention to the consideration of the screw as a means of transmitting power. The paper was illustrated by formulæ and diagrams. The discussion was participated in by Messrs. Russell, Nipher, Johnson, Robert Moore, Baier, Seddon and Ockerson.

Under general discussion, Mr. Robert Moore showed the club some cubes of clay taken from the bottom of the Mississippi river at Memphis, where piers for a new bridge were being constructed.

Prof. Johnson gave the club some data regarding recent tests of granitoid beams, which showed that a mixture of six parts of granite to one of Portland cement was stronger than mixtures having larger proportions of cement. This matter was discussed by Messrs. Russell, Crosby, Seddon and Colby, after which the meeting adjourned.

Wm. H. Bryan, Secretary.

ASSOCIATION OF ENGINEERING SOCIETIES.

ORGANIZED 1881.

Vol. IX. June, 1890. No. 6.

THE CHICAGO RAILWAY PROBLEM, ESPECIALLY IN RELATION TO TERMINALS, RAPID TRANSIT AND THE AVOIDING OF ACCIDENTS AT STREET CROSSINGS.

I.

PAPERS BY OSSIAN GUTHRIE, A. F. ROBINSON, AND RICHARD P. MORGAN, MEMBERS OF WESTERN SOCIETY OF ENGINEERS.

[Read May 7, 1890.]

BY OSSIAN GUTHRIE.

The phenomenal growth of Chicago has precipitated demands for changes and improvements in such rapid succession that precipitate action has been forced upon us, and under these circumstances methods of temporary relief have been inconsiderately adopted. Many of these have proved utterly worthless, others have afforded temporary relief. But not in a single instance have we kept pace with Chicago. Our city and railroad systems have grown up together; each has benefitted the other. Adjustments and re-adjustments have followed in rapid succession like checker men through a strongly contested game, until the contestants are both in the "King-row" and the solution of the game is involved in the next move. We are in a complicated snarl which the next move must untangle. To one even, who has witnessed all of these marvelous changes, the retrospect is bewildering. Although not coming to Chicago until 1846, I have, perhaps, more nearly than any other person, witnessed the

entire growth of this wonderful city. The great fire of 1871 destroyed nearly every building which had been erected before my arrival. Therefore. thinking that experience would shed the clearest light upon, and that I could more efficiently promote the discussion of the subject before us, "The Chicago Railway Problem," by giving a historical sketch, than in any other way, I ask your indulgence for a few minutes for that purpose.

I landed in Chicago October 28th, 1846, then a city of 14,000 inhabitants.

Public Works.

The Court House, at that time, was a two-story brick structure about 40 × 100 feet and stood on N. E. corner of the Public Square, then an open common. The Jail, a wooden structure and much smaller than the Court House, stood on the N. W. corner of the Square. There was a total of about *one mile* of improved or planked streets, the balance being only graded like a country road. There was a float bridge at Clark Street, one at Randolph Street and a draw or lift bridge at Kinzie. There was also a small scow ferry at Rush Street. These structures were all of exceedingly rude construction. Chicago then had but two Public Schools and three hand fire-engines. This catalogue comprehends the public works of Chicago at the close of the year 1846. Total enrollment 1,000.

October 5, 1847.—The following petition signed by Henry B. Clarke, C. Wilder, Wm. Oaks, and O. Jackson, was presented to the Common Council:

"Your petitioners would respectfully ask your Honorable Body to assist us to procure a suitable place for a school, in the south part of Districts Nos. 1 and 2. We have had a good school under your appropriation of $100, for the last six months, and as the school is about to close, we are very anxious to have it continued. The building we have used is upon a lot that costs no rent; the building belongs to W. F. Merrick, for which he asks the sum of $35. Your petitioners believe that with a twelve foot addition made to it, and lathing and plastering, it would be sufficiently large and comfortable for the winter. Should your Honorable Body see fit to appropriate the sum of $100 and allow the use of the old stove of the Council room, the building could be bought and all the necessary repairs made. Your petitioners desire that their petition may be referred to the Committee on Schools, in whom your petitioners have confidence."

October 8, 1847.—The following order was passed:

"*Ordered*, That the sum of $100 be appropriated from the School Tax Fund for the purchase, enlargement and repairs of the building which has been occupied during the past summer as a school house, in the southern part of School Districts Nos. 1 and 2, in accordance with the prayers of the petitioners; to be expended under the direction of the Trustees of Districts Nos. 1 and 2."

The most conspicuous among the notable private enterprises of Chicago was Frank & Walker's Stage Office at the corner of Lake and Dearborn streets. From this corner the overland passenger traffic of the Northwest, radiated. The passenger traffic by the Lake, however, was her distinguishing feature during the season of navigation. The daily arrival and departure of magnificent side-wheel steamers was heralded by bands of music—each steamer carrying its own band.

Notable Private Enterprises.

About 1843 private enterprise erected the Hydraulic Mills at the corner of Lake street and Michigan avenue. This establishment was a combination of flouring mill and pumping works. Water from these works was supplied through three-inch wooden mains running through the alleys, to that part of the South Division North of Madison Street and East of La Salle. The reservoir was a wooden structure about 25 × 50 feet deep. It might, perhaps, be described as an overgrown tanner's vat, above ground. A complete section of the old wooden pipe, with its iron connecting thimbles, may now be seen at the Department of Public Works.

The source of supply from these works was supplemented by a water cart service with headquarters for the South Division at Van Buren Street and the Lake. McCormick's Reaper Works, then Gray and McCormick, was located on the West Side of Dearborn Street near Madison. There were three foundries and machine shops. These foundries "poured" once or twice a week each, as occasion required and patterns were carried from one to the other when dispatch demanded.

Here let me add that, to Charles R. Vandercook, Chicago is indebted for the first foundry which poured daily. This was a notable event in her history.

There were then three elevators operated by horse power, the horse working a treadmill on the roof.

The great lumber market was located on Market Street between Randolph and Madison Streets, and Foss Bros' Planing Mill was located at Madison Street and the river. Here all the planing of Chicago was done. Foss Bros' owning the Woodworth Patent, controlled the entire planing business of Chicago.

There were then but six steam engines all told, in operation.

There were two steam flouring mills, one of which, the Hydraulic Mills, has already been mentioned. There were four of the principal hotels.

The most notable event of those early days, was the opening of the Illinois & Michigan Canal by the arrival of the freight boat, General Fry, on May 10, 1848. A line of Packet-boats had been built, and was started on that day. A boat capable of carrying 100 passengers arrrived and departed every morning and night. This year is also notable for the introduction of a Tug-boat on the Chicago River, the writer being the engineer. Since that time, events have crowded upon us with such rapidity that memory is confused.

Heretofore we have groped along in uncertainty, not knowing whether we were to lay the foundation for a City of a quarter, and ultimately to a half million or not. All this doubt and uncertainty is now removed and in its stead we have before us a clearly indicated duty, viz. to so project all future enterprises and changes, as to form a part of a gigantic, but as yet, indefinite whole, — to lay the foundation for a City ranging from one, to indefinite millions of population.

The necessity and wisdom of adopting such methods seem to be clearly illustrated by the changes which have taken place within my personal observation and to some of which I have called your attention.

From the last report of the Commissioner of Public Works, we find Chicago now has 578 miles of thoroughly improved streets, and as many miles of water pipe, and 45 bridges. She has over 200 Public Schools with a total enrollment of 128,000. These public features of her growth, when compared with the data just given relating to the same features in 1846, form a bewildering contrast; and yet, her private enterprises far exceeded those of a Public character. It seems to me that nothing further need be said to demonstrate that the time for immediate action had already arrived. We are confronted to-day with three stupendous enterprises, upon which the future of Chicago greatly depends, viz. Perfect Drainage and Pure Water, the "Railway Problem" and the World's Fair.

There is scope enough in either of these great projects perfected, for a generation. The first of these, it is believed, has a foundation already laid broad enough for any requirements of the future, and under the able direction of our worthy President, will proceed to completion.

The Railway Problem this society has well in hand, and before dropping it, will doubtless present the most satisfactory solution possible; and in relation to the World's Fair, I believe we have only to fear that the work will be underestimated. This must not be. The World's Fair must be a success, and this Society must "bear a hand".

By A. F. Robinson.

Steel Viaducts With Brick Piers.

(four tracks).

The writer had occasion recently to make an approximate estimate of the cost of a four-track brick viaduct. He has re-modeled this estimate, and added others for four-track metallic viaducts with brick piers. These are now offered to the Society with the hope that they may be useful in connection with the Rapid Transit question which is now up for its consideration.

Regular steel spans are 45 feet between centers of piers, 15 feet from base of rail to street grade, 5 feet 10 inches from base of rail to clearance line under side of girder. Girders for one track 8 feet centers, tracks 14 feet apart between centers.

For street crossings use two through spans of 35 feet each for one track supported at the middle of the street by trestle bents resting on concrete piers capped with stone. The clear head room above street grade is about 12½ feet. The distance from base of rail to clearance line over streets 2 feet 6 inches. Depth of ballast between top of floor and bottom of ties is 5½ inches in all cases. The material in girders is soft steel, used without reaming.

To support these spans, brick piers laid in cement mortar are used.

The regular piers are 56 × 5 feet under coping, by 9½ feet high from under side of coping to footing. Batter is one-half inch per foot all around. Coping is 18 inches thick with 6 inch projection. There is a concrete hearting through neat work and the footing (3 feet thick) is of concrete. Total height of pier from top to bottom of footing is about 14 feet.

The girders are figured for heaviest typical engine loads. The equivalent uniform moving loads are from 5,000 pounds to 6,000 pounds per lineal foot of track.

ESTIMATE.

One Regular Pier.

19 cubic yards stone coping @ $18	$ 342.00
57 cubic yards brick work @ $8.25	470.25
122.58 cubic yards concrete @ $6.75	827.42
107.4 cubic yards excavation @ 35 cents	37.59
Total	$1,677.26

Small Pedestals for One Street Crossing.

3 cubic yards stone coping @ $18	$ 54.00
15.25 yards concrete @ $6.75	102.94
20 yards excavation @ 35 cents	7.00
Total	$ 163.90

One 45 Foot Span, Deck Plate Girder.

(four tracks.)

152,000 pounds steel work erected and painted @ 4.3 cents	$ 6,665.00
1,890 cubic yards ballast (rolling mill slag) @ 50 cents	945.00
1,080 feet B. M. pine guard timbers, etc. @ $30	32.40
Total	$ 7,642.40
Cost per lineal foot	$ 169.83

Eight 35′ through spans with bent for middle of street:

313,600 lbs. steel erected and painted @ 4.3c	$13,484.80
Cost per lineal foot (clear street)	204.31

Cost Per Mile of Above Four-Track Structure (Counting Upon Eight Street Crossings Per Average Mile.)

Superstructure.

18,971,560 lbs. steel erected and painted @ 4.3 cents	$ 815.777.08
199,401 cubic yards ballast @ 50c	99,700.75
222,720 feet B. M. pine in guard timbers @ $30	6,681.60
Cost of one mile of superstructure	922,159.43
Cost of superstructure per lineal foot	174.65

Substructure.

(144 regular piers and 40 small piers.)

2190 cubic yards stone coping @ $18 ....$	39,420.00
5498 cubic yards brick work @ $8.25	45,358.50
14096 cubic yards concrete @ $6.75	95,148.00
12404 cubic yards excavation at 35c	4,341.40
Cost of one mile superstructure ....$	184,267.90
Cost of superstructure per lineal foot of viaduct	34.90
Total estimated cost of one mile of viaduct ....$	1,106,427.33
Total cost per lineal foot of finished viaduct ....$	209.55

If space under regular girders was made into rooms they could be rented for various purposes, as floor space under each span will be 2028 square feet, having a clear height of 9 feet 2 inches. A very low rental for these rooms would be $18 per month, or $216 per room per year. In an average mile of viaduct there are 105 of these rooms, which, at the above rental, would bring $22.680 per annum. The cost of putting in end walls, concrete floors, doors, windows and other fittings would be, say $60,000 per mile, making a total investment of $1,169,427.33 per mile of four-track viaduct. The rooms at above rental would give a return of nearly 2 per cent. on the total investment.

A viaduct differing from the above only by having ordinary floor, that is, timber ties will cost per mile of the superstructure alone $540,261.42 including heavy ties and guard rails. Ordinary track ties for a four-track line will cost about $6.000 per mile. Deducting this from above we have for comparison the cost of superstructure per mile with ordinary floor—$534,261.42 or $101.19 per lineal foot as against $174.65 per lineal foot of superstructure having solid steel floor and regular ballast. With ordinary floor on viaduct the space beneath girders will hardly rent for more than one-third what it brings when solid floor and ballast are used.

Estimated Cost of Brick Viaduct.

(four-tracks).

The brick viaduct is made up of a series of arches with steel girders at street crossings. The span adapted is 20 feet at springing lines of arch; rise in centre, 4 feet; pier, 6 feet thick. The footings and core in piers and floor on ground surface below arches made of concrete; remainder of work is made of the best hard brick laid in cement mortar, the space under arches being enclosed by 9 inch walls at ends, thus making it available for storage. The distance from base to rail on viaduct to street grade is taken at 15 feet; distance from street grade to springing lines of arches, 7 feet 6 inches; minimum thickness of filling between bottom of tie and crown of arch is about 14 inches. Alleys or unimportant streets could be crossed by the regular arches, but these have not been considered in the estimate. The same plan for crossing streets is used as in previous estimates, and eight street crossings are taken for the average mile of viaduct, leaving 181½ spans of brick viaduct. At each street crossing piers of double thickness have been used, thus we have regular abutment piers nearly every 600 feet.

Cost of One 20-foot Span and One Pier.

5.42 cubic yards stone coping @ $15	$ 81.30
226.67 cubic yards brick work @ $8.50	1,926.70
109.93 cubic yards concrete @ $6.75	742.03
145.89 cubic yards rough filling @ 35 cents	51.06
67.07 cubic yards ballast (slag) @ 50 cents	33.54
96.75 cubic yards excavation @ 35 cents	33.86
1.250 ft. B. M. timber guards @ $18	22.50
500 pounds iron bolts and connections @ 4¼ cents	21.25
Water-proofing per span	175.00
Cost of 26 lineal feet	$3,087.24
Cost per lineal foot	118.74

NOTE.—Rough filling is between top of arch and lower line of ballast.

Cost of One Mile of Finished Viaduct.

(181½ regular spans and eight street crossings.)

2,508,800 pounds of steel erected and painted @ 4½ cents	$112,896.00
344 cubic yards stone coping @ $17	6,192.00
983.73 cubic yards stone coping @ $15	14,755.95
42,759.01 cubic yards of brick work @ $8.50	363,451.59
21,517.82 cubic yards concrete @ $6.75	145,245.29
26,479.8 cubic yards rough filling @ 35 cents	9,277.68
13.334.17 cubic yards ballast @ 50 cents	6,667.08
17,720.13 cubic yards excavation @ 35 cents	6,202.05
53,760 feet B. M. timber guards and fastenings @ $30	1,612.80
226,875 feet B. M. timber guards @ $18	4,083.75
90,750 pounds iron bolts and fastenings @ 4¼ cents	3,856.88
Water-proofing 181½ spans @ $175	31,762.50
Cost per mile of viaduct	$706,003.57
Cost per lineal foot of viaduct	113.71

The cost of concrete floor under arches and enclosing walls at ends was included in the above estimate, but not the doors, windows and other necessary fittings. For the above items add, say, $20,000 per mile, making a total cost of viaduct per mile $726,003.57. The rooms under arches will contain 1,080 square feet floor surface. They are 7½ feet high at lowest point. These rooms should be worth $120 per annum rental; 181 rooms at $120 per year will give an income of $21,720, which is equal to about 3⅓ per cent. of the entire cost per mile of viaduct.

In above estimates nothing is added for engineering superintendence and legal expenses, neither is any allowance made for interference with existing surface arrangement of yards, etc., while building.

When tracks are elevated some of the connections with important industries will, no doubt, be cut off. At many of these places it is now very difficult to get in sidings giving sufficient car storage room. The latter difficulty may be in great part overcome and connection with road maintained by the use of elevators with short lifts capable of handling the heaviest loaded car. An elevator of 50 tons capacity and from 14 to 20 feet lift will cost for an entire plant ready for operation from six to eight thousand dollars. For a portion of the way at least some of the side tracks

will have to be elevated. The elevated connection can be made with these and a double storage room for cars thus be obtained.

Cars could be moved on these covered or house tracks by means of the stationary engines (in every factory) using spools and return pulleys at various places in the yard.

At a large elevator in one of our eastern cities the writer has seen the above methods of using stationary engine and rope for doing the shifting of cars in actual operation. There were three or four tracks along the full length of the warehouse, which was some 600 or 800 feet in length; all shifting of cars for loading or unloading grain was done with the stationary engine. Locomotives were never called for except when a train was ready to go out from the elevator.

By Richard P. Morgan.

It was stated at the Grand Pacific Hotel last evening by a gentleman (perhaps from New York City) that Chicago would be the most populous, salubrious and moral city in the world. He admitted, however, that before his prophecy could be fulfilled, several great problems must be solved in physical and spiritual engineering.

The drift of affairs in the world seems to indicate that the task of solving the physical problem, at least, is likely to fall to the lot of "The Western Society of Engineers."

The far reaching importance of the subject for discussion to-night, "The Chicago Railway Problem" and the vast difficulties that surround a feasible, comprehensive and satisfactory solution of it, admonish us to approach it with care, yet every engineer may endeavor to throw light upon the field of operation, for who can alone fully illuminate the subject? If there is any one willing to make that claim, he must be very capable or audacious.

An examination of the present occupation of the central territory of Chicago discloses remarkable conditions which probably must be regarded as permanent and very arbitrary. It therefore seems that civil engineers who may engage themselves on the solution of "The Chicago Railway Problem," must accept these conditions as the base of their plans, because any that might be devised, contemplating a radical change in them, would antagonize capital instead of meeting and winning it.

The investments already made by existing railroad companies, in the purchase of terminal properties, and the construction of buildings and facilities for the transaction of business, are so large and valuable that any plan which proposes entirely new methods, or to do away with such expensive structures, cannot be expected to be acceptable to the companies interested in them.

The central territory alluded to may be bounded on the north by Kinzie street, on the south by Sixteenth street, on the east by the lake and on the west by Canal street.

Of this area, which is two miles in length and one in width, approxi-

mately 35 per cent. is owned and occupied by the great railway systems terminating in Chicago, and 15 per cent. of it is occupied by the Chicago river, its docks, slips, grain elevators and other warehouses and Lake Park, leaving fifty per cent. only occupied by the streets and buildings.

Stated in another form this tract contains two square miles or 1,280 acres, of which one-half or 640 acres is covered by the existing railway systems terminating in Chicago and by the river docks, elevators, etc., and Lake Park. It will be seen therefore that the business centre of Chicago which is practically within the boundaries before mentioned occupies only 640 acres, including the streets.

There are about eight miles of dock frontage and perhaps twelve miles of railway, not including second and terminal tracks, within the area described. The railway tracks connect with the river front mainly on the west and north side of this central portion of the city bringing lake and rail transportation together very completely.

It is not likely that even so great a sum as several hundred million dollars would induce these railway companies to relinquish their several positions connecting with lake transportation and which are so eligible to the present principal business district of the city.

What has been said perhaps shows sufficiently the permanent and arbitrary conditions spoken of. It may, however, be of service, in elucidating the subject under discussion, to compare them with those in other cities.

The city of New York, with an area south of Harlem river more than ten times as great as the central territory of Chicago spoken of, and having a population of 1,800,000, is penetrated by only one of the great railways of the country and the passenger terminus of that is three miles from the post office and city hall; also this road from the Grand Central Depot at Forty-second street, to Harlem river, four and one-half miles, is a continuous combination of underground, open cut and viaduct systems of railway construction, thus completely freeing the streets of that city from interference by even that one railroad. In addition to the passenger line leading to Forty-second street its freight line extends on the west side of the island and city as far down as what was formally known as Hudson Square.

The proportion of the area of New York owned or occupied by this road is comparatively very small, indeed infinitesimal, yet every locality of the city by reason of its peculiar geography, enjoys unsurpassed facilities for the receipt and delivery of persons and property from all parts of the world. The width of Manhattan Island at no point exceeds about two miles and it is surrounded by navigable waters, so that all persons, supplies or property, coming in or going out, easily pass between the water and their place of destination.

A vast proportion of the weight and bulk of all the property coming to and going from New York is moved by water and the exchanges of heavy and bulky articles are made near the water frontage. A comparatively small proportion only of the foreign commerce of the city and also of its local traffic and supplies have an average haul by horses of so much as half a mile.

These conditions dispense with the necessity of constructing elevated or underground steam railways, except for the rapid transit of persons between different parts of that city.

The wonderful terminal facilities that the water front of New York affords, considered in connection with the rapid transit of persons which is furnished by its elevated system of railroads, measurably disclose the character and capacity of the terminal and rapid transit facilities that will be demanded at an early day by the commerce and people of Chicago.

As no means of public transportation can be devised which will receive and deliver goods and other property at the warehouses, stores and dwellings, of each individual, the necessity of drayage must always exist, but it seems clear that the terminal railroad system of Chicago should be such as to reduce the average drayage distance to a minimum, even below that of New York. But Chicago, unlike New York, must have railroad transit for property as well as for persons. Generally considered that is possible of attainment by one of three methods.

1st. Below the level of the streets by tunnels or their equivalents.

2d. Upon a new avenue to be opened for the railroad itself through existing blocks, and the road so elevated as not to interfere with the streets it may cross.

3d. By using the lines of the present streets and avenues so as not to interfere with their present occupation.

It is possible that these systems in their varying forms can be profitably used in combination, or it may be best or necessary to some extent to do so; but either separately or in combination, it seems manifest that they furnish the only feasible means for the safe and rapid transit of persons and property in the city of Chicago.

The vast commercial capacity that New York has in its dock frontage must be created for Chicago upon the land, by the erection and proper distribution of capacious warehouses and terminal railway facilities to supply the needs of a great and increasing commerce which approaches the city by land. The fact that no man can fix a limit to this commerce, points to the necessity of establishing a system of terminal facilities that can be uniformly extended from time to time, also without limit.

Assuming that the termini of the existing roads must remain as they are, the problem becomes one of enlarging the terminal facilities for the commerce of the city, from time to time, as the growth may demand. Certainly the present gorged condition of the central territory described cannot be much more intensified for the terminal facilities are already overcrowded.

The embarrassment of the ordinary traffic of the city and danger to human life occasioned by surface tracks at crosssings should prohibit any extension of the present methods.

If a belt line of elevated railroads were built surrounding the district described, at a uniform distance of a mile, and so adapted in its construction as to connect with the present surface roads, all of which it would cross, as well as the streets, without obstruction, and in the same manner cross the elevated rapid transit passenger roads, an increase, at least, of the present evils would be avoided. In this way a satisfactory system

might be established which could be extended from time to time with the growth of the city, so that its facilities for receiving and delivering property could be increased with the demand for them. On all parts of these belt lines warehouses could be established and the surface drayage thereby reduced to a minimum.

If it be objected that the plan proposed would be expensive and complex, the truth of the objection must be admitted. On the other hand it also must be admitted that the present condition of the terminal facilities in Chicago are insufficient, unsatisfactory and expensive, and that the necessities of the city are therefore very stringent.

Such vast difficulties cannot be overcome by trifling appliances. The means must be adequate to the solution of the problem, both in the location and capacity.

The surface belt lines are necessarily so remote from the internal business that they answer mainly the single purpose of exterior exchange of cars between the roads centreing in the city.

It seems, therefore, that some such system as suggested is demanded by the rapidly increasing needs of the foreign and local commerce of Chicago. If Chicago is to be as populous and commercially great as there is reason to anticipate, we need but a full disclosure of the capacity of the terminal facilities of New York, so briefly alluded to, to demonstrate how totally inadequate those existing in Chicago are.

RECENT PROGRESS OF THE METRIC SYSTEM.

By B. A. Gould, Member for the U. S. A. of the International Committee of Weights and Measures, and President of the American Metrological Society.

[Read before the Boston Society of Civil Engineers, March 12, 1890.]

Few subjects have deeper interest for me than the furtherance and extension of the Metric System of Weights and Measures, now almost universal among civilized nations; and knowing how decided a position, relative to this reform, your Society has taken in past years, it is probable that I might have chosen this topic of my own accord if called upon to address you.

In the early part of the year 1870, it became my duty to leave home for a distant part of the world upon an expedition, which, although expected to continue for only three years, did protract itself through fifteen.

When I went away, the crusade in behalf of the Metric System was active and earnest. Soon afterwards, my letters told that our leading engineers and architects had united in the resolve and pledge to use this

system exclusively in their plans, specifications and drawings; thus making it necessary for our mechanics to familiarize themselves with it, and insuring its general use. I was informed that the leading physicians had agreed to employ it in their prescriptions, and that the most prominent constructors of machinery had already undertaken such modifications of their apparatus as were needful for putting their enginery into accord with the metric units.

Returning home, less than five years ago, it was with the expectation of finding the metric weights and measures in general use; and all the more because I knew that instruction concerning them had been required at our schools, and a knowledge of them for admission to many of our colleges. There is no need of telling how great was my disappointment at finding the usages of our community scarcely more advanced than they had been fifteen years before.

The agreement among professional men proved to have been contingent upon the accession of a certain stipulated number in our principal cities. The instruction had heen discontinued in many schools, in the desire of diminishing the excess of demands upon the pupils. The national laws, enacted to promote the gradual introduction of the system, had been practically nullified by other legal provisions, which by devices of administrative interpretation, were made to override them. And, strangest of all, a little sect had sprung up,—endowed with far more zeal than knowledge, which, following the honest but absurdly mistaken ideas of Mr. Piazzi Smyth, maintained that the British inch, and the British so-called "quarter," had been the subjects of divine revelation, and which persistently closed their eyes to the great movement which was animating the rest of the world, and tendiug toward a fraternity among nations in this important respect.

The first crusade had failed; yet only by a narrow margin. And it did good work. During the last eighteen or twenty years our people have acquired vastly more knowledge of the subject, and greater breadth of view. The commercial classes have begun to recognize the advantage which they would derive from the accord of our weights and measures with those of other nations. The mistakes in those pyramid measurements, and in the inferences from them, have been brought to light. And the strange relics of colonial provincialism, which have so persistently clung to our nation—although an excess of conservatism has not generally been prominent among its faults,—are manifestly tending to disappear. Moreover the almost unanimous accord of all other civilized nations, except Great Britain, has not been without its influence upon our community. Yet, how great that accord is may not, even now, be fully recognized.

At this moment there is but one first-class nation of continental Europe in which the metric system is not obligatory. This is Russia, where, however, metric units are largely in use among the higher classes, and whose representatives have not hesitated to say that their government only awaits the adoption of the system by either the United States or Great Britain, to follow at once. In the Grand duchy of Finland, of which the Russian Emperor is sovereign, the metric system is obligatory to the exclusion of all others. And, in all the European continent, the only remaining na-

tions which have not adopted it exclusively, are Denmark, Greece and Turkey, in two of which the legal units are nevertheless based upon the meter and the gram.

Throughout South America the metric system is definitely established for all government purposes, with the sole exception of the British Colony of Guiana, and it has been largely introduced in Asiatic countries.

In short, the legal adoption of metric weights and measures by our own country is all that is needful to insure its practical universality throughout the civilized world, with the single exception of England, where of course it cannot be looked for, until her isolation in this respect shall have compelled it.

But enough of this for the present. What I had purposed saying was in a totally different vein. The Boston Society of Civil Engineers needs no information as to the importance and advantages of the metric system. But it may, not improbably, be interested in what has been done for its advancement during the past year.

For fourteen years the International Committee of Weights and Measures—a body composed of fourteen, in those rare cases when no vacancies exist, and no two members of which may be of the same nationality—had been commissioned by the International Diplomatic Conference of 1875 to prepare prototypes which should secure uniformity in the standards of the meter and kilogram throughout the world, and provide for the minute comparison of these with other existing standards. For this purpose it has maintained a Bureau near Paris, upon land which has been ceded for the purpose by the French Government, and declared international territory. And its modest outlays have been defrayed by annual contributions from the constituent nations.

This Bureau has until the last year been under the immediate directorship of some member of the Committee; but in September last its management was confided to Dr. Benoit, a man of exceptional ability, who had, for many years, been an efficient assistant.

Problems of high physical importance, which had previously baffled investigators, have here been successfully solved by the Bureau itself, or at its instance, by specially competent investigators. Not only balances, comparators and other apparatus have been prepared with a delicacy previously deemed unattainable, but chemical methods for obtaining the requisite purity in the metal employed for the prototypes; optical methods for securing minute exactitude in linear measurement, by the interference of light waves of different length; principles and forms for barometers and thermometers to obtain the higher precision than was previously possible; new methods of graduating; apparatus for securing the maintenance of any desired temperature—all these, and other analogous devices, have been brought to bear upon the several problems. And it may fairly be asserted that there is no branch of science or of the arts connected with the work of this Bureau, in which important advances have not been attained in consequence of the demands thus made upon it.

The instructions given the International Committee by the conference which it represents, required the preparation of an international prototype for the meter and for the kilogram, which should represent the

original meter and kilogram of the Archives of France as nearly as possible. Also the preparation of a sufficient number of similar standards to satisfy the requirements of all the constituent nations, and of course a minute comparsion of these so-salled *national prototypes* with the international ones.

The material and form for these prototypes were the subject of much study and discussion. It was finally decided that the form of the meter-bars should be such that their transverse section should be something intermediate between a capital H and an X, and of such proportions that the upper surface of the middle or cross-piece should form the medial or neutral plane, so that its length should remain unaffected by any partial change of temperature in the bar itself; while at the same time such change should be conveyed to all parts of the bar as rapidly as possible. The form of the kilogram-standards was prescribed as a cylinder of height equal to its diameter, slightly rounded at the edges. It was further provided that the material should be an alloy consisting of 90 per cent. platinum and 10 per cent. iridium, with a tolerance not exceeding 2 per cent. in either.

But the practical attainment of the required conditions, as regarded the material, seemed, for many years, to be out of the question. No chemical process known could give either platinum or iridium of the needful purity. It became imperative to reject large quantities of material previously supposed to be free from noxious impurities. But at last, after six or seven years, the ingenuity of the chemists, Stas and Deville, devised the process by which metals can be obtained with a degree of purity even higher than that demanded. And thus the material was obtained, from which the prototypes of mass and length have been constructed. The quantity of chemically pure platinum varies only between the limits, 89.81 and 89.90 per cent.; that is, by only an eighteenth of the permitted tolerance in the extremest case. And the of iridium varies only between 10.09 and 10.10 per cent., or by one-half the tolerance; while, far more important even than this, there is practically no extraneous matter. There is not a trace of ruthenium, a harmful metal most difficult to separate from the other, nor more than $^1/_{100}$ of 1 per cent. of rhodium and iron together.

Then, as regards the success with which these new prototypes of almost indestructible material and carefully devised form, have been made to represent the old *Metre des Archives* and *Kilogramme des Archives* in their length and weight. This is such that it has been found impossible to discover in which sense the variation exists. Weighed in air the *kilogramme des Archives* is perceptibly lighter, owing to its greater volume and the consequent greater buoyancy of the air. The difference varies with the temperature, but disappears when the correction is applied for reducing to weight in a vacuum, as it also does when the weighings are effected in the vacuum-balance. The error of observation cannot amount to 2 micrograms, that is, to the $^1/_{500}$ part of a milligram. It is certain that a few rubs with the finger covered with a kid glove would suffice to diminish the weight of the prototype by an appreciable amount, notwithstanding that its material is nearly (if indeed not quite) the hardest known. An

analogus statement may be made concerning the international prototype for the meter. The probable error of the comparison will not exceed 0.1μ* and although especial and quite serious difficulties were encountered because the *metre des archives* is an end-meter, or *metre a bouts* while the prototypes are line-meters, *metres a traits*, which give the length as the distance between two finely-graduated lines, still it is not probable that the difference can exceed the limit mentioned. Not only has the greatest care been bestowed upon the microscopic comparisons, but very delicate optical methods have been employed for the same purpose, using the method of interference fringes. At any rate, it may be asserted of this prototype, as analogously for that of the kilogram, that the difference between its length and that of the original in the Archives of France is too small to be detected by any method known to the International Committee, and that it is not known which of the two is the longer, at the standard temperature.

Last September a new conference met at Paris, composed of about forty delegates from eighteen of the constituent nations. The first session was at the Ministry of Foreign Affairs, and all diplomatic courtesies were cordially extended by the President and ministers of the Republic. At subsequent sessions the President of the French Academy presided. On Sept. 26, 1889, the international prototypes were unanimously accepted and formally adopted; and were thereupon deposited in a subterranean chamber, built for the purpose and fastened by three locks, the keys of which were delivered respectively to the custodian of the Archives of France, the President of the International Committee and the Director of the Bureau. From that day on, there has existed for the whole world but one metric standard for length, and one for mass; and the French originals, which have heretofore served for ultimate recourse, have no longer any legal authority even in France itself, possessing only a historic value.

With the international prototypes were deposited two other prototypes of each kind, elaborately compared with the former, as also several thermometers of hard glass, which had been adjusted to the hydrogen scale.

Of the national prototypes for delivery to the constituent nations, 31 meters and 39 kilograms had been prepared and were distributed by lot. Every meter was accompanied by two hard-glass thermometers, each with a table referring each graduation to the hydrogen scale, and likewise by a piece of the metal cut from the end of the same bar, for possible future testing of the coefficient of expansion. Every kilogram was provided with a plate of rock crystal for it to rest upon, and, of course, with appliances for its safe transportation and handling. Attested certificates of the comparisons with the international prototypes were delivered with them.

As limit of difference between the national prototypes and the international ones, 10 microns had been prescribed for the meters; but for none of those distributed did this difference exceed 2.8μ. Those which

*μ is one micron, or one-thousandth part of a millimeter.

fell to the lot of the United States are respectively 2.5μ in excess and 1.6μ in defect. The probable error of determination is below 0.2μ.

For the kilograms the limit of difference established as permissible was 1 milligram, but in none of those distributed did the difference reach 0.28 milligram. The probable error of a determination is 5 micrograms.

I may add that the average density of the platiniridium is 21.51, and the average volume of a kilogram prototype is about 46.15 milligrams.

In the early weighings a curious fact became palpable, which indeed, ought to have been anticipated; and which has led to the substitution of the word *mass* instead of weight, in all the subsequent publications of the committee. The force of terrestrial gravity was found to vary perceptibly at the different balances; indeed, the weighings show an appreciable difference between the weights of the two kilogram standards when one rests upon the other, and when they are placed in the pan side by side. This will readily be appreciated when it is remembered that for 1 centimeter of greater altitude the force of terrestrial gravity for a kilogram is diminished by 0.003 milligrams. And since 0.001 milligrams can be recognized in a series of weighings, and the centre of gravity of the two prototypes is higher in one case than the other by half the height of one of them—which exceeds 3 centimeters—the phenomenon was soon explained. The force of gravity at the Bureau has recently been carefully determined by the French army engineers, and the employment of the word "mass" removes all difficulty,

The national prototypes having now been distributed, the Bureau is able to give its attention to other important, although less pressing, matters. And it is now undertaking the study of two very interesting questions closely connected with the metric system. It is preparing to define the meter by a natural unit, although different enough from the one originally proposed. Within the next 12 or 18 months, I trust that, for more than one well-known ray of monochromatic light, the number of waves which corresponds to a millimeter will have been determined, with an error of not a single wave. We shall then have the definition of the meter in easily reproduced natural units, and subject to no appreciable change while the records of civilization shall exist upon our planet. The other problem alluded to is a careful determination of the difference between the kilogram and the theoretical value. Arrangements have long been making, and now are essentially complete, for determining, as it never could have been determined before, the mass of a cubic decimeter of pure water at the temperature of its greatest density. And the discovery of that exact temperature, now only vaguely known, will be among the collateral results.

Furthermore, researches are now going on for the determination of the degrees of the alcohol thermometer in terms of the adopted hydrogen scale for temperature between zero and eighty degrees below.

I have dwelt probably too long on this work of the International Committee, gentlemen, because of my desire that you should be fully aware of the refined accuracy of its results, and of the wide extent to which the metric system has already been definitely adopted; nothing standing in the way of its universality among civilized nations except the prejudices of

the English-speaking people, and their reluctance to make changes, even for the better, when their pecuniary advantage is not conspicuous.

Speaking to a society which has already advocated the introduction of the metric system in a manner, and at a time which has insured it a most honorable place in history, and to men whose professional pursuits are constantly tending to impress upon them the importance of the reform, I need say nothing in its behalf. But I am most desirous of using this opportunity to urge upon you that now is the time for renewing an earnest and vigorous effort in its behalf. There may be some who have been disheartened at the failure of previous attempts, but such must remember that our people have acquired much information upon the subject since the former crusade. The silly grounds of opposition to it have crumbled away in consequence of their intrinsic weakness, and the visionary ideas of Piazzi Smyth have now comparatively few adherents.

The American Metrological Society has recently awakened from its lethargy of the last few years and has resolved to make another earnest effort. It now calls for help—not so much for the important pecuniary aid which will come from accession to its membership, enabling it to print tracts and employ some salaried officer who shall devote all his energies to their judicious distribution, as for the still more efficient contribution of active personal exertion in advocating the reform, enlisting the sympathies of those now lukewarm, and convincing those who have never been awakened to its importance.

It is time now that clubs or societies should be organized in our principal cities to devise and execute plans for arousing public interest. Our law-makers must not be expected to act until they are stimulated by public opinion in their several constituencies.

There are many ways of bringing this about, and the influences are far more favorable now than they were when the movement, twenty years ago, came so near to success. That the reform must come before many years shall have passed, is evident, but we must not forget meanwhile, that the sooner it takes place the fewer will be the inconvenience of the change, and the speedier the realization of its benefits.

THE SUBSTRUCTURE OF THE CAIRO BRIDGE.

By Edward H. Connor, Member Engineers' Club of St. Louis.

[Read February 19, 1890.]

The word bridge carries to the public the idea of airy structures spanning rivers or ravines at greater or less altitudes. Little thought is given to the masonry or foundations reaching, perhaps, as far below the waters' surface as the highest point of the superstructure is above.

Engineers whose duties are not directly in the line of bridge building and even those engaged in such work, frequently overlook the importance of the substructure.

Evidence of the greater attention paid to the superstructure is borne by the greater number of books written upon the designing of that portion.

However the tendency of late has, fortunately, been to devote more time, thought and money to bridge piers and their supports.

The floods of 1889 undermined many piers having shallow, unstable foundations and forcibly showed the necessity of better designing of this part of the structure.

A good foundation must give sufficient supporting power and also insure against the destruction of that power. The formation of the river bed at Cairo made this a difficult and expensive thing to secure.

The Cairo Bridge spans the Ohio River about four miles above its mouth, or at the upper end of the city of Cairo, Illinois. It is a single-track railroad bridge built by the Illinois Central Railroad Company.

Mr. Geo. S. Morison was the Chief Engineer, Mr. E. L. Corthell, Associate Chief Engineer and Mr. Alfred Noble, Resident Engineer.

The Union Bridge Company had the contract for the entire bridge. The foundations were put in by Messrs. Anderson and Barr, the masonry laid by L. M. Loss, the superstructure of the main spans erected by Baird Bros. and that of the approaches by the Union Bridge Company with their own employes.

Work on the foundations was commenced in June, 1887, and the bridge opened to travel Oct. 28, 1889.

The superstructure of the bridge proper consists of 12 steel spans of the following lengths between centers and end pins, commencing on the Kentucky shore, viz: 1 span 249 feet, 7–400, 2–518½ and 2–249. The 249-foot spans were deck, single quadrangular or Pratt and the others through, double quadrangular or Whipple trusses.

The 10 piers supporting the 400 and 518½-foot spans are in the river, are similar in design and have foundations, sunk by means of pneumatic caissons, 75 feet below low water. They are numbered II to XI from the Kentucky shore.

The masonry starts 25 feet below low water, at least 10 feet below the river bed.

The 249-foot spans extend over the slopes of the banks and the levees. They rest on three smaller piers having pile foundations.

The lengths of spans used gave a clear opening in the channel spans at low water of 500 feet and a distance of 4,644.5 feet between centers of end piers.

The bridge charter required the lowest point of the superstructure to be 53 feet above the level of high water, as established by the U. S. Engineer Department, or 105.2 feet above low water.

The tops of the river piers are 102 and the centres of the bottom chord end pins 106½ feet above the latter level.

The low land on both sides of the river necessitated long approaches.

There is no grade on the bridge, it being necessary to keep the 53 feet of headroom the entire width of the river as in high water boats going up stream keep near the Kentucky shore, out of the main current. The channel is close to the Illinois shore, near the concave bank of the stream, which there makes a long circular bend.

It was not deemed expedient to contract the river at the bridge site owing to the great destruction of life and property which would result should the levee surrounding Cairo be injured. The streets of the city, back of the levee, lie from 5 to 20 feet below high water.

The Kentucky approach consists of 21 spans 150 feet, and 1 span 106 feet 3 inches long, centre to centre of end pins, and 4,594 feet of timber trestle. The Illinois approach contains 17 spans 150 feet, and 1 span 106 feet 3 inches long and 5,327 feet of timber trestle.

All approach spans are single track, deck, steel, Pratt trusses, resting on piers composed of two steel cylinders, filled with concrete and bearing on piles. Portions of both approaches are on a 5° curve and their grades are 39.6 feet per mile on tangents and 30.1 feet on curves.

The formation of the river bed is that of the delta of a stream flowing through an alluvial soil. In 1881 borings were made to determine the character and depth of the material through which it would be necessary to pass to secure a solid foundation.

Although the deepest of these was carried down 196 feet below the river bed nothing of a solid nature was encountered. The material pierced was sand, gravel and clay, with some loose rock at a depth of 175 feet.

In 1886 the I. C. R. R. Co. made soundings and cross-sections of the river bed for a distance of 1½ miles above and below the adopted site.

After a careful study of the conditions Messrs. Morison and Corthell decided to use, to secure foundations, caissons sunk by the plenum pneumatic process, which has been so successfully employed by the former on seven large bridges over the Missouri River. The many logs lying buried deep in the sand and the possibility of striking steamboat wrecks excluded the use of the open caisson lowered by dredging, and the loose character of the bed and swift current during high water made the use of piles to support the piers of such an important structure hazardous.

The pneumatic caisson certainly makes the safest and most stable

foundation for bridge piers in large rivers. No work is done which is not visible to the eye of the engineer and hence no doubts exist as to the actual character or excellence of any part.

In estimating the supporting power at Cairo reliance was placed on both the frictional resistance of the material passed through on the vertical walls of the caisson and the bearing on the sand at the base. The former was assumed at 400 pounds per square foot of surface exposed to friction and the latter at 6,000 pounds per square foot due to the fatigue weight (*i. e.* the actual weight less the weight of the displaced substances) on the foundation.

To locate the piers, a base line was selected on each side of the river, with one end on the bridge line and the other on the bank of the river at a point from which all the river piers were visible.

The Illinois line was about 3,400 and the Kentucky line about 2,400 feet long. Each was measured twice with a Chesterman 100-foot steel tape supported only at the ends. Thermometers and tension scales were used. The measurements were taken after sunset.

The two results obtained on the Illinois line varied 0.005 and those on the Kentucky side 0.006 feet although both lines ran over levees and rough ground. The triangulation was done with a Wurdeman transit reading to 10 seconds. Each angle was read 15 times and the average error of the triangles from closing was 1.5 seconds. The computed length of the Kentucky base line, assuming the length of the Illinois line and the adjusted angles to be correct, varied from the measured length 0.02 feet.

The terminals of both base lines being on land below high water mark necessitated the building of cribs, filled with earth, 5′ to 20′ feet high for observation stations.

The caissons of the three piers supporting the 518½ foot spans were 30′×70′. The remainder were 26′×60′. All were 16′ high with a timber crib work the full size of the caisson built on in sections to a height of 50′ from the cutting edge. In the following description the numbers of braces and timbers given apply to the larger foundations, the smaller ones being of the same general design.

The outside walls of the caissons were vertical and built of one thickness of 12″×12″ timbers, ranging in length from 10′ to 43′, so arranged as to break joints several feet. Two courses of oak plank 3″ thick were spiked onto the outside by at least two spikes, 7″×⅜″, to each square foot in each course. The first course was planed and put on at an angle of 45°; the outside planks were left rough and placed vertically.

The walls of the working chamber sloped at an angle of 45°, were built of 17″×17″ timbers and lined inside with one thickness of 3″ pine plank. The timbers, by an ingenious joint, pass each other at the corners and extend into the outside walls. All timber used was yellow pine from Mississippi, except the outside planking. The working chamber and outside walls were fastened together by sixty 1½″ iron rods placed perpendicularly to the sloping timbers.

The courses of the outside and also of the inside walls were bound together by drift bolts 30″ by ⅞″ square, driven into holes ⅞ of an inch

in diameter, 3′ apart. The roof of the chamber, 8′ above the cutting edge, was built of two courses of 12″ × 12″ timbers, laid crosswise of the caisson, bolted together at their ends by 1″ bolts, and supported by the sloping walls. The outside walls were braced at the bottom in the working chamber by four horizontal cross-timbers, and one longitudinal 16″ × 16″; eight posts 12″ × 12″ extended from the cross-braces to the roof. On each side of each cross-brace was a 2″ rod tightened by nuts on the outside. Above the roof the walls were braced by alternate courses of three longitudinal and nine cross-ties of 12″ × 12″ timbers dovetailed into the outside walls. At every intersection of these braces with the outside walls an iron rod, 2″ in diameter, passed vertically the entire height of the caisson and crib-work. Similar vertical 1½″ rods passed through the timbers where they rested on one another.

The crib work was built on in three sections of 12′ and 10′ each. At the top of each section the vertical rods had a washer and a turnbuckle to connect them with the next section of rod. The corners of the caissons were rounded off to a radius of 18″, and iron plates, ⅜″ thick and 30″ wide, spiked on with 10½″ spikes.

The walls of the working chamber were caulked and treated to two coats of white lead to prevent leakage of air and aid in illuminating the interior. The outside walls were caulked to the top of the caisson proper, 16′, or higher, to keep the space above the roof dry while putting in concrete below the surface of the water surrounding the caisson.

The shoe was made of iron plates ⅜ of an inch thick, and was 36″ deep. Twenty-four inches from the cutting edge was an iron shelf 24″ wide supported by brackets 2′ apart. From this shelf the timber walls started. The shoe was fastened to the timber by two rows of 10″ × ½″ spikes at the outside, and 10″ × ⅝″ lag screws, spaced 18″, passing up through the shelf on the inside. The cutting edge was strengthened by a 5″ × 1″ iron band.

The main shafts 3′, and the supply shaft 2′ in diameter, were built into the caisson and carried up through the concrete and masonry until the sinking was completed. To the inside of the main shaft an iron ladder was bolted, affording means of ascending from and descending into the chamber.

The air lock was made of ¼″ iron plates and was placed in the crib-work 8′ above the roof of the working chamber. It was 9′ long, 6′ wide and 7′ high, with circular ends having a radius of 3′. The ends were separated from the centre compartment which was itself divided into two spaces 3′ square. One of the latter had a circular hole leading upward and the other one downward. Each end was connected with each centre room by an air tight door, and formed a lock independent of the other.

One air pipe 4″, three discharge pipes 4″, and one water pipe 5″ in diameter were also carried up through the timber, concrete and masonry.

The caissons were built to a height of 16′ on the Illinois shore about three-fourths of a mile below the bridge site, this being the nearest available, suitable point, and towed to position by tugs. While being built the caissons were blocked up on six skids, or launching ways, 12″ × 12″ tim-

bers, which were nearly horizontal at the upper end and gradually increased in slope to about 3½ to 1.

The ways extended into the river to a depth of 7′ below the lowest stage of water at which any caisson was launched, the usual depth being much greater than that. On shore the timbers were placed on blocks and held in line by plank driven into the ground each side of them at the joints. In the river they were supported by two pile bents, to which they were fastened by drift bolts.

Considering the facts that so many caissons, extending over such a long period of time, were to be there launched, and that the ways were nowhere above high water, which softened the ground at times, it would probably have been more economical to have put the ways on a pile foundation their entire length. They were uneven and unstable at times, and therefore caused trouble.

When ready for launching the caissons were pushed with jacks and held straight by lines, fastened to the shore side, till the steeper grade was reached, when they went with a rush and a plunge into the river. In some caissons a false bottom was placed on the horizontal braces in the working chamber and braced from the roof. Thus arranged the caisson drew temporarily several feet less water than otherwise, and was more easily floated off the ways. This was necessary only during low water.

The majority of the caissons went into the river with a grand plunge, but several stuck on the ways, owing to the poor condition of the latter, and had to be pulled off by tugs, injuring the iron shoe in one or two instances.

A clump of three piles was driven about six feet from each corner of the permanent position of the caisson in the river, and by means of lines fastened to these piles the position of the caisson could be controlled while it floated. When, on account of the concrete filling, the caisson began to touch sand it was located in its proper place by the ropes and two transits, one at each end of the base line. As soon as it was well into the sand and the concrete filling several feet above the water, sinking was begun. As the foundation sank crib-work was built on top, and concrete deposited in it at the same time, the timber being kept one section above the concrete to enable the vertical rods to be connected at the top of each section.

The sand in the working chamber was removed by the use of Monson sand pumps, and by blowing out with the air pressure. The action of the Monson is similar to that of the Eads sand pump, but it is simpler in design and more efficient. In blowing out material a pile is heaped about the lower end of the pipe extending into the caisson having a valve near its lower end. When this valve is opened the pressure of air forces the sand in large quantities and with great velocity through the pipe; or, the pipe may be extended below the level of the water in the bottom of the chamber, and the sand being stirred up, sand and water force out together. When the sand is blown out dry the loss of air is always considerable.

At pier XI. on the Illinois shore, the bed of the river was found paved with sunken logs which had to be cut up and taken out through the lock. This required about two weeks. Large logs were encountered in several

other cases. One, in pier IX., was four feet in diameter and extended the entire length of the chamber. It was an oak tree in sound condition about 40 feet beneath the bed of the river.

On the Kentucky side a layer of very hard clay from 1 to 3 feet thick was encountered 60 feet below low water. The greater part of this was worked up into balls and passed out through the wet blow-out pipe, and some of the hardest was "locked out."

This work was necessarily slow. Such material was not expected, and when struck a clay hoist could not be secured in time to be of advantage.

The maximum sinkage in 24 hours was 10.63′ at pier VIII. The usual progress in clean sand was 2′ to 4′ daily. The average daily progress for the time during which air pressure was kept on was 1.1′ at pier XI., and slightly over 2′ at pier II.

The maximum depth below the water at which work was carried on was 94.2′ at pier IV. The time required by the workmen to pass through the lock was never over five minutes.

The caissons were located by transits after every sinkage of 8′ or 10′. They were easily moved in position by lowering the side opposite to the direction in which it was desired to move the pier, sinking the entire structure in this unlevel position, when it would slide down and toward the high side, and then releveling. At pier II, however, some difficulty was experienced in doing this. The pier was the one nearest the Kentucky shore. So much excavated material was deposited on the land side that when it was desired to bring the pier, leaning toward the river, to a vertical position, the lateral pressure of the sand prevented. Material was then pumped from under the cutting edge along the shore side and thrown into the river on the opposite side. Blocks and tackle were attached to a line, passed around the pier and to trees or "dead men" on shore and a strain taken on the line till the outward thrust was counterbalanced. But the pier was then one foot too near shore. The other caissons were settled within a few inches of the desired positions.

High water delayed the sinking in many instances but caused the most trouble at pier IX. When the cutting edge of that caisson was about 10′ in the sand the river rose so rapidly that the contractors were unable to keep the concrete above the water and work was necessarily suspended with the concrete about 6′ from the top of the crib work. The shafts were kept above the water and a Λ shaped timber guard built on the up-stream end of the caisson as a protection against drift. The river quickly scoured out a hole to the cutting edge at the up-stream end and as there was no probability of finishing the concrete that season it was decided to sink the foundation 10′ more, or until the the top of the caisson was only 12′ above low water, to secure it and to leave it till the following summer. About 1,000 cubic yards of rip-rap and sand bags were deposited in the hole scoured out. Thus this foundation remained from January, 1888 until August of that year, out of sight but not out of mind.

In order to finish the contract within the allotted time two outfits of pressure machinery were necessary. One was placed on a flat bottomed barge 130′×24′, housed over; the other on the steamer "Emma C. Elliott" which was purchased for the purpose. The former plant consisted of:

Three boilers, 60 h. p. each; 1 single acting Cameron pump; steam cylinder 18″×24″, water cylinder 14″×42″; 1 single Delamater air compressor 10″×12″×24″; 1 duplex Delamater air compressor 10″×10″×16″; 1 duplex Clayton air compressor No. 3, 10″×10″×16″; 2 air receivers 2′×8′ and 3′×5′; 1 Barrow steam engine to run dynamo; 1 incandescent light dynamo.

The latter outfit comprised the following:

Four boilers of the boat; 1 duplex Delamater pump, 18½″×10½″×14;″ 2 No. 4 duplex Clayton air compressors; 2 Barrow engines to run dynamos; 1 incandescent light dynamo; 1 arc light dynamo; 1 air receiver 3′ 4″×10′.

The men for pressure work were arranged in gangs of from 8 to 14 men depending upon the character of the material. Sinking was always continued night and day. No serious accident happened in connection with the caisson work.

When pier II was within a few inches of the required depth it was necessary to blow off air from the working chamber to permit the caisson to sink, although all material had been removed from under the cutting edge. Therefore the frictional resistance on the sides could be obtained from the following data:

Penetration in sand	86.42 feet.
Immersion in water	90.27 "
Weight of caisson	887 tons.
Weight of crib	3163 "
Weight of masonry	2800 "
Weight of sand and water	1806 "
Total weight	8656 "
Indicated air pressure, before sinking	42.75 lbs.
Calculated " " "	39.117 "
Indicated air pressure lowered to	36.00 "

From these the following are deduced:

Air pressure	42.75	39.117	36
Reaction due to air pressure	4802	4394	4044
Net weight, tons	3854	4262	4612
Surface in contact, square feet	12910	12910	12910
Net weight per square foot exposed to frictional resistance, lbs.	597	660	715

In obtaining the above weights the following were assumed per cubic foot: Yellow pine, soaked, 50 pounds, concrete 145, masonry 150, sand 127, water 62.4. We thus see that the net weight per square foot exposed to frictional resistance was about 700 pounds. Other instances, less precise, gave results in excess of this. The material here passed through was principally clean sand, with some gravel, and thin layers of sandy loam. The friction was on 36′ of rough masonry as well as the 50′ of the vertical caisson walls.

For depths less than 75′ below the water surface no danger to human life need exist in pneumatic caissons. For depths of from 75′ to 100′ there is possibility of loss of life, but this is reduced to a minimum if the

proper precautions are taken. At Cairo five deaths were due to the effects of the compressed air.

In sealing the first caisson, at a depth of 77′, several of the men were temporarily paralyzed, and two lost their lives. Afterward a different method of working was employed with better success. One room on the pressure boat was fitted up for the men, with a stove and coffee pot, so that every one could have a cup of hot coffee on coming out of the caisson. A hot bath was also provided. While sealing one caisson a man carried in hot coffee a few minutes before the gang came out. No serious illness occurred while this was continued.

But the easiest, cheapest and most efficient prevention of caisson disease found, was to cool the air before it entered the caisson. This was done by passing the compressed air through a number of 1-inch pipes coiled in a box into which water was pumped from the river and overflowed constantly through a pipe near the top of the cooler.

The air passed from the receiver through a 4-inch pipe connected at the cooler by a T with 16 inch pipes 100′ long. The air was thus reduced in temperature from 125° to 95°, where it entered the caisson.

The heavy air pressure affects the men in two different ways, *i. e.*, with what is commonly termed the "bends," and with paralysis. The former is very painful, but not dangerous. It consists of a severe aching of the limbs, lasting from a few minutes to several days. While it lasts sleep is impossible. Rubbing the limb vigorously affords temporary relief.

Paralysis is not so painful but very dangerous, death resulting if it reaches the internal organs. It frequently passes off in a few minutes, and in other cases lasts months or till death ensues.

The working hours of pressure men at divers depths were as follows:

Depth of cutting edge below surface.	No. of Shifts of each gang per day.	No. of hours worked per shift.	No. of hours rest between shifts.
0 to 50 feet	1	8	16
50 to 60 feet	1	8	16
60 to 70 feet	2	3	9
or	1	6	18
70 to 80 feet	2	2	10
over 80 feet	2	2	10
sealing	2	2	10
or	2	1½	10½

The original intention was to sink all piers to 75′ below low water, but this was slightly altered. Pier II. was sunk 66′ and pier III. 69′ below, the river bed at those points being several feet above the lowest stage of the river.

The concrete was mixed on a barge 87′×30′, anchored alongside of the caisson, hoisted up in buckets of 24 cubic feet capacity and dumped into the pockets of the crib work. Two buckets and fifty men were employed in concreting. Six men were constantly spreading and ramming

the concrete. About 2′ in depth was put in a pocket each move of the scow.

The mixing was done as follows: The sand was spread out on deck, the cement put on top of it, the two completely turned over once with shovels; then turned over on the broken stone spread out near the mixing machine. The whole mass was then thrown or shoved into the hopper of a Cockburn and Barrow concrete mixer, where the water was added. The water was supplied by a small pipe leading from a tank into the mixer, the flow being regulated by a valve to suit the supply of dry concrete.

The mixing machine had the hopper level with the mixing deck, stood on a lower deck, and deposited the concrete in buckets standing in the hold of the barge. The hoisting engine used here had two $7'' \times 12''$ cylinders.

The sealing of the working chamber, or the filling of it with concrete, was accomplished by means of a hopper bolted to the top of the supply shaft. The hopper had a door at the top and the shaft one at the bottom, both opening inward. These formed a lock operated by valves, on the sides of the hopper, turned from the outside. Usually but one bucket of concrete was taken in at one time, as it was liable to stick in the bottom of the shaft if more was put in. All shafts were left in the masonry, except the main shaft above one section above the lock. The latter was enclosed in boxing through the concrete and masonry and easily removed. The lock was necessarily left buried in the concrete.

The shafts were left empty from the roof of the working chamber to two feet below low water and the concrete started from the latter elevation on a wooden bulkhead, or the shafts were filled with sand to that point.

In the concrete from the roof to two feet above and for a depth of one foot at the top of the crib work Portland cement, Alsen brand, was used. Between these layers Louisville cement was employed. In the filling of the working chamber Portland cement was used in the lower eighteen inches of concrete and in the 6″ layer of mortar rammed under the projecting shelf of the steel shoe, crossbeams and roof. The mortar was placed with unusual care and force, forming a smooth, solid-bearing surface.

The Portland cement concrete was made of cement one part, sand two, broken stone two. The Louisville concrete consisted of cement one part, sand two, broken stone $3\frac{2}{3}$.

The cement was all tested before being used. Ten samples were taken from each carload and the cement accepted or rejected by carloads. The tests were made on a Riehle machine in accordance with the method recommended by the American Society of Civil Engineers and with great care. The mortar was pressed into the molds with the fingers and finished off with a pointing trowel. No tamping was permitted. The briquettes were allowed to set 24 hours in the air under a wet cloth and 6 days in water. Many tests were also made to ascertain the influence of various conditions and substances on the strength of cement. The results are very interesting and are given in the tables at the end of this article.

The sand was dredged from the river bed near the bridge site. The stone used was limestone from Ullin, Ill., crushed to about the size of walnuts.

An inspector was constantly employed overseeing the mixing, distribution and ramming of the concrete. During sealing of caissons all of the engineers took turns at this work.

On the completion of the work it was found that the volume of the Portland concrete was 9% less than the aggregate volume of the materials employed in its formation and that of the Louisville concrete 32.5% less than the corresponding volume. The greatest number of cubic yards placed in 10 hours was 230.

The masonry is of a very superior character. The stone was obtained from the limestone quarries at Bedford, Ind., and was subjected to a rigid inspection before being laid. This oolitic limestone is of a remarkably homogeneous structure, it being impossible in many instances to distinguish the natural bed without the closest examination. The specific gravity varies from 2.45 for the brown to 2.52 and 2.53 for the white and blue varieties respectively. The ratio of absorption is 0.032 for the blue, 0.039 for the brown and 0.062 for the white.

The up-stream nose stone was granite in all courses between high and low water. The courses ranged in thickness from the bottom upward as follows: Five courses 3′, twenty-five 2′ 6″, six 2′ 3″, sixteen 2′, belting 1′ 9″ and coping 2′ 3″.

The masonry detail plans were made at Cairo and the size of each face stone of each course so fixed as to break joints the required 15 inches or more. These plans were sent to the quarry and each stone before shipment was there marked as to its exact position in the pier.

The face stone was laid in mortar composed of Portland cement one part, sand two, and the backing in mortar of Louisville cement one part, sand two parts. In freezing weather salt was added to the mortar to delay freezing and only Portland cement was then used. Tests made did not warrant the use of Louisville cement at such a temperature.

The face stones of the up-stream starting between high and low water, were joined to the course below by dowels, $1\frac{1}{8}'' \times 12''$, extending 6″ in each course. The face stones of each course for the three courses immediately beneath the coping were bound together by cramps of round iron, $\frac{7}{8}'' \times 20''$, with claws sunk 3″ into the top beds.

The starling coping is placed at high water mark or $87\frac{1}{2}'$ above the base of the masonry. All headers had a face length of 3′, or a trifle more, and a breadth of 4′ to 6′; the stretchers had a length as great as 8′ and a usual breadth of 3′.

A large derrick boat was built by the contractor especially for laying masonry at such heights as 102′ above low water. The boat is $85' \times 45'$ by 5′ deep. The derrick mast is a single stick 71′ long, 18″ in diameter at the butt. It stands on a well-braced framework $22\frac{1}{2}'$ above the deck. The boom is $12'' \times 12''$ by 90′ long and rests in a seat fastened to the mast 30′ above the deck. The mast is braced by three stiff guys which are connected by a system of $3'' \times 12''$ plank.

The proportions of face stone and backing masonry in the piers was a

surprise to many. The total and relative amounts for the different sizes of piers were as follows:

PIER. NO.	CUBIC YDS. MASONRY IN PIER.	PER CENT. OF TOTAL, FACE STONE	PER CENT. BACKING.	HEIGHT OF MASONRY IN FEET.	AV. AREA OF PIER IN SQUARE FT.
XII	447.0	83.0	17 0	142	287
III	2712 7	58.3	41.7	221	605
X	3846.5	53.0	47.0	127	815

The ratio of the perimeter to the area as well as to the actual volume of the course are evidently factors of the relative proportions of face stone and backing masonry in a course or pier.

The materials used in one cubic yard of masonry were:

1. For face stone masonry:

Stone	0.975	cubic yards.
Portland cement	0.030	" "
Sand	0.053	" "
Total	1.058	cubic yards.

2. For backing masonry:

Stone	0.710	cubic yards.
Louisville cement	0.096	" "
Sand	0.194	" "
Spalls	0.089	" "
Total	1.089	cubic yards.

The center of the pier was located by transit and the outline of the next course laid out every four or five courses.

Rip-rap was placed about the up-stream ends of the channel piers.

Piers I, XII and XIII are on land and support the shore ends of the 249′ spans. They have pile foundations. A pit was excavated about 12′ deep and 94 piles were driven into the bottom 20′ to 25′. These were sawed off level and the ground removed to 2′ below their tops. A bed of concrete 18′×38′ and 4′ thick was then put in in layers of 6″ to 8″ and well rammed between the piles.

The piles were white or burr oak at least 11″ in diameter at the small end, the majority being much more than that. Portland cement was used in the concrete in the same proportions as elsewhere.

A record was kept of the number of blows expended on each pile and its sinkage for every 10 blows.

The approach spans rest on steel cylinders filled with concrete. Each pier consists of two cylinders, 8′ in diameter, placed 18′ center to center and connected by a cross-frame of rods and angles.

The cylinders are made of ½″ plates, spliced on the inside.

For the foundations of each cylinder a circular pit was dug 8′ deep and 12 oak piles were driven in it. The pits were then filled with concrete to the proper elevation for the base of the steel cylinders, the cylinders placed in position, concrete rammed about them in the pit, forming an

exterior ring 6″ thick, the cylinders filled with concrete and capped with a ½″ steel plate. The surface of the concrete was leveled off ½ of an inch above the top of the cylindrical steel shell.

The upper two feet of concrete inside and that of the exterior ring was made of Portland cement one part, sand one part, into which stone was rammed after the mortar was in place. The remainder of the concrete was made up of Louisville cement with the usual proportions.

Anchor bolts 5′ long were built into the concrete and passed through the cap and bed plates.

The accompanying tables are:

1. Weight on Foundations of Channel Piers.
2. Weight on Foundations of River Piers.
3. Weight on Concrete Base of Foundation Pier XII.
4. Bill of Iron and Weight for One Caisson.
5. Gauge Readings of Ohio River at Cairo, Ill., 1872–1888.
6. Effect of Freezing on Strength of Louisville Cement Mortars.
7. Effect of Salt on Strength of Cement Mortars.
8. Effect of Fine Grinding on Strength of Louisville Cement Mortars.
9. Effect of Setting between Porous Beds on Louisville Cement Mortars.
10. Tensile Strength of Portland Cement Mortars with Varying Proportions of Limestone Screenings.
11. Tensile strength of Natural Cement Mortars.
12. Tensile Strength of Portland Cement Mortars.
13. Quantities of Materials used in Masonry.

In making table No. 1, the quantities in pier IX were used; in table No. 2 the quantities in pier VI. The weights on foundations given in those tables are in excess of the actual as the sand extends from 10′ to 30′ higher than the level there assumed.

The drawings given are:

I. Elevation and Plan of Bridge.
II. Elevation and Plan of Caisson.
III. Sections of Sand Pump and Air Lock.
IV. Elevation and Plan of Piers IX, X, XI.
V. " " " " " II, III, IV, V, VI, VII, VIII.
VI. " " " " Pier XII.

The specifications are appended as being valuable for reference.

TABLE No. 1.

Weight on Foundations of Channel Piers.

	Tons.	Tons.
330,990 feet B. M. lumber @ 50 lbs. per cubic foot....	689.6	
Iron 137,000 lbs....	68.5	
77,345 cubic feet concrete @ 145 lbs per cubic foot...	5,607.5	
102,508 cubic feet masonry @ 150 lbs per cubic foot..	7,688.1	
Superstructure, one 518½′ span....	1,027.0	
523.5 lineal feet of train @ 3,000 lbs. per foot....	785.2	15,865.9
Deduct:		
Sand displaced below 25′ below low water; 105,000 cubic feet @ 127 lbs. per cubic foot....	6,667.5	
Water displaced above 25′ below low water; 29,070 cubic feet at 62.4 lbs. per cubic foot....	907.0	
Frictional resistance of sand on side of caisson; 10,000 square feet @ 400 lbs. per square foot....	2,000.0	9,574.5
Total fatigue weight on foundation....		6,291.4
Weight per square foot of foundation		3.00

TABLE No. 2.

Weight on Foundations of River Piers.

	Tons.	Tons.
264,640′ B. M. lumber @ 50 lbs per cubic foot....	551.3	
Iron; 124,500 lbs., average weight	62.2	
55.505 cubic feet concrete @ 145 lbs. per cubic foot..	4,024.1	
77,884 cubic feet masonry at 150 lbs. per cubic foot.	5,841.3	
Superstructure, 400′ span	555.1	
405 lineal feet of train at 3,000 lbs. per foot....	607.5	11,641.5
Deduct:		
Sand displaced below 25′ below low water; 78,000 cubic feet at 127 lbs. per cubic foot....	4,953.0	
Water displaced above 25′ below low water; 22,756 cubic feet at 62.4 lbs. per foot	710.0	
Frictional resistance of sand on sides of caisson; 8,600 square feet at 400 lbs. per square foot....	1,720.0	7,383.0
Total fatigue weight on foundation		4,258.5
Weight per square foot of foundation		2.73

TABLE No. 3.

Weight on Concrete Base of Foundation Pier 12.

	Tons.
12,072 cubic feet masonry at 150 lbs. per foot....	905.4
Superstructure; one 249′ span and connecting stringers....	234.6
253′ train at 3,000 lbs. per foot....	379.5
Total weight on concrete	1,519.5
Total weight per square foot....	4.03
Total weight per square inch....	56.0 lbs

TABLE NO. 4.

BILL OF IRON AND WEIGHT FOR ONE CAISSON.

30′ × 70′ × 50′.

DESCRIPTION.	No. of Pieces required	W'ght of one P'ce lbs.	Total Weight. lbs.
Cutting edge	1	26583	26583
Corner plates (lin. ft.)	190	42 7	8108
Air locks (1 pair doors left in)	1	7287	7287
Supply locks	——	1298	——
Sections of main shaft below lock	1	1462	1462
" " " above "	1	1249	1249
Supply shaft, bottom sections	1	1671	1671
" 8′ 10″ "	8	1220	9760
" 4′ 0″ "	1	671	671
Rods 2″ × 15′ 4″, 2 nuts and 1 turnbuckle	28	187.6	5253
" 2″ × 11′ 8″, 1 " 1 "	56	141.6	7930
" 2″ × 9′ 4″, 1 "	28	106 2	2973
" 2″ × 29′ 8″, 2 "	8	323.5	2588
" 1½″ × 14′ 9″, 2 " 1 "	8	103.2	826
" 1½″ × 9′ 4″, 2 " 1 "	19	72.5	1378
" 1½″ × 11′ 8″, 1 " 1 "	54	81.9	4425
" 1½″ × 8′ 3″, 1 "	27	56.7	1530
" 1½″ × 8′ 3″, 2 "	20	55.6	1112
" 1½″ × 6′ 10″, 2 "	20	47.8	955
" 1½″ × 5′ 6″, 2 "	20	39.7	793
" 1″ × 4′ 4½″, 1 "	16	12.8	205
" 1″ × 2′ 4½″, 1 "	80	7.27	582
Washers for 2″ rods, 12″	156	24.6	3841
" " 1½″ rods, 9″	255	10.3	2637
" " 1″ rods	96	3.31	318
" " 1″ rods countersunk	96	3.28	315
Drift bolts ⅞″ × 30″	3402	6.25	21132
" ⅞″ × 22″	100	4.73	474
Boat spikes ⅜″ × 7″		0.29	12229
" ½″ × 10″		0.69	3173
Lag screws ⅝″ × 10″	310	0.85	265
Bolts 1″ × 1′ 6″	2	5.25	10
" ¾″ × 2′ 6″	13	4.23	55
" ¾″ × 3′ 6″	4	5.75	23
" ¾″ × 0′ 3″	228	1.06	243
Pipe 4″, lin. ft.	334	10.5	3495
" 5″, "	83	14.9	1234
Total			136785

TABLE No. 5.

Gauge Readings of Ohio River at Cairo, Ill., Giving Yearly and Monthly Means and Extremes on U. S. Gauge, 1872-1888. Zero of Gauge 269.58′ Above Mean Gulf Level.

Year.	January.					February.					March.					April.					May.					June.				
	Mean.	Highest.	Date.	Lowest.	Date.	Mean.	Highest.	Date.	Lowest.	Date.	Mean.	Highest.	Date.	Lowest.	Date.	Mean.	Highest.	Date.	Lowest.	Date.	Mean.	Highest.	Date.	Lowest.	Date.	Mean.	Highest.	Date.	Lowest.	Date.
1872	9.9	15.2	13	4.5	29	9.0	15.4	27	4.4	11	15.0	17.5	20	13.3	11	30.2	39.2	20	14.7	1	20.7	26.4	1	15.0	14	21.3	24.7	15	17.5	30
1873	16.6	23.0	29	8.5	4	28.4	41.5	26	14.2	7	26.9	41.0	1	19.5	14	35.4	40.6	12	27.0	30	30.5	38.7	17	25.7	26	26.1	33.0	1	24.2	28
1874	20.3	32.4	31	11.9	7	29.5	41.0	28	20.7	13	39.8	44.0	11	36.3	22	41.0	47.4	26	33.4	8	31.9	46.0	1	14.6	31	14.5	18.2	22	10.8	11
1875	14.7	24.6	8	5.3	26	19.7	27.4	8	11.5	25	40.2	43.7	2	26.2	1	29.3	40.4	1	24.4	28	28.5	37.6	7	20.2	31	21.9	28.7	30	17.4	5
1876	33.5	43.0	31	20.5	17	42.7	45.2	5	32.2	29	31.8	46.4	31	19.1	9	42.0	46.4	6	37.5	30	35.3	42.2	15	26.5	31	28.5	32.6	19	24.5	15
1877	18.7	37.0	28	1.0	1	20.4	32.5	1	13.0	28	23.0	30.7	31	11.7	7	34.1	40.5	15	31.7	1	32.1	38.3	1	23.6	31	27.0	30.8	20	21.2	3
1878	21.9	27.0	4	15.5	15	21.6	32.9	28	25.0	11	30.9	35.7	17	21.3	31	25.0	37.0	29	19.5	5	30.6	35.8	1	26.6	20	26.3	29.1	1	24.1	30
1879	20.2	36.0	26	7.9	9	28.6	34.1	9	22.0	19	27.6	32.9	27	23.2	11	30.0	31.8	1	21.8	30	14.4	21.0	1	12.0	28	16.8	18.1	7	14.6	1
1880	35.8	41.7	15	24.8	31	31.8	43.3	25	19.1	11	41.9	44.6	22	38.8	6	32.9	37.9	1	30.0	17	27.3	38.1	6	18.6	29	23.2	26.8	29	20.0	19
1881	17.1	32.6	28	5.4	7	32.9	42.4	25	18.5	7	35.3	41.1	11	29.0	13	40.8	45.8	20	36.1	5	36.2	42.6	9	23.9	31	24.6	30.8	22	20.7	5
1882	42.1	47.6	31	37.1	10	47.4	51.9	26	44.2	15	44.2	51.0	1	41.3	28	34.7	41.9	1	29.4	25	37.8	42.5	23	30.8	8	38.2	42.0	6	32.4	18
1883	17.8	30.7	30	13.0	14	41.8	52.2	27	28.9	6	35.5	51.8	1	24.3	26	39.9	44.2	16	26.4	1	31.2	41.6	1	23.7	17	35.7	39.3	25	31.5	8
1884	28.3	35.3	3	23.1	16	46.7	51.8	22	25.6	1	40.0	49.5	1	36.1	11	40.4	48.0	1	37.3	30	31.6	38.3	9	21.4	31	24.0	26.8	18	20.5	4
1885	33.2	39.0	26	26.5	1	23.3	27.9	16	15.9	28	20.0	31.7	18	16.5	1	29.5	38.2	21	21.2	3	26.2	36.8	1	20.1	28	28.5	30.8	22	24.1	1
1886	25.9	30.2	11	18.0	2	30.9	38.5	21	20.7	10	26.8	38.3	31	20.4	20	46.3	51.0	19	32.6	30	32.6	39.9	18	24.8	6	24.1	29.5	30	20.3	11
1887	17.1	32.1	31	10.9	17	43.6	47.1	28	34.0	1	41.3	48.6	10	22.1	31	21.2	38.6	30	18.0	20	28.2	39.3	2	17.7	31	18.4	23.2	19	15.0	6
1888	20.0	27.9	20	1.8	1	22.3	28.9	28	17.8	3	28.3	43.9	31	23.3	13	38.1	45.3	3	24.9	30	26.2	31.1	31	23.9	5	27.6	32.4	6	24.0	17

TABLE No. 5. (Continued.)

July.					August.					September.					October.					November.					December.					
Mean.	Highest	Date.	Lowest.	Date.	Mean.	Highest.	Date.	Lowest.	Date.	Mean.	Highest.	Date.	Lowest.	Date.	Mean.	Highest.	Date.	Lowest.	Date.	Mean.	Highest.	Date.	Lowest.	Date.	Mean.	Highest.	Date.	Lowest.	Date.	Mean for year.
17.7	22.0	29	14.1	16	13.3	21.7	1	10.1	26	6.2	9.7	1	4.5	25	3.6	5.6	1	2.4	31	4.5	6.8	11	2.2	2	4.1	12.8	29	1.0	6	13.0
24.1	29.1	14	18.0	31	11.5	17.6	1	7.7	27	5.6	8.1	1	2.9	30	2.9	4.5	31	2.6	17	9.7	13.4	30	5.4	19	26.0	33.5	18	14.1	1	20.4
11.2	13.7	1	10.2	23	8.4	13.0	7	5.0	27	7.1	13.8	6	3.3	21	5.6	7.9	2	4.5	31	5.3	12.0	30	3.0	19	9.8	16.6	31	6.8	22	18.9
32.8	41.4	23	29.3	1	35.6	45.1	8	14.0	31	15.1	19.3	25	11.0	10	9.6	14.5	1	6.5	31	11.2	21.4	30	5.8	4	19.3	28.5	31	13.2	24	23.5
30.8	34.2	10	20.8	31	16.0	20.6	1	14.9	20	19.2	23.9	21	13.5	3	12.0	22.5	1	7.8	25	11.3	13.4	6	9.0	2	4.9	12.3	2	1.1	31	25.5
23.2	29.3	2	18.3	31	11.2	17.7	1	6.8	31	6.6	7.5	6	5.5	30	5.6	11.2	31	3.4	12	13.3	18.8	30	10.1	2	18.3	24.1	31	14.3	23	19.7
21.2	25.3	8	16.9	30	15.8	18.8	3	12.8	23	11.2	18.4	23	6.7	20	6.8	10.6	1	6.1	10	8.5	10.6	30	6.3	1	20.9	27.4	14	12.5	2	20.6
16.9	19.7	5	15.1	26	13.5	15.5	1	11.5	24	12.0	19.5	7	4.2	30	4.1	7.7	27	2.7	10	8.1	15.8	23	3.4	10	24.8	30.5	31	14.3	1	18.0
26.5	34.1	9	16.8	31	11.4	16.0	1	7.8	26	10.7	14.5	12	7.8	27	7.5	9.4	7	6.1	30	11.1	16.6	14	5.7	30	19.6	31.5	12	6.2	11	23.2
21.0	25.5	7	16.3	31	9.9	15.5	1	6.1	31	7.4	11.6	29	5.4	10	19.0	23.0	29	11.4	1	20.0	33.2	24	22.3	1	28.6	39.5	31	20.0	15	25.0
32.0	38.8	9	21.0	31	19.1	23.1	9	13.7	3	14.5	15.3	9	10.5	30	9.1	10.0	1	8.0	20	10.9	12.2	8	9.4	1	11.0	17.0	3	7.3	19	28.2
27.9	38.7	1	19.6	31	16.3	21.6	5	11.1	31	6.8	10.5	1	4.7	30	8.3	11.3	31	4.7	1	20.4	28.1	30	12.9	1	21.1	33.5	31	13.1	23	25.1
20.5	23.0	11	15.5	28	13.6	19.0	4	8.8	30	9.1	11.8	5	7.1	23	17.1	19.6	5	15.0	1	11.7	16.0	1	9.4	25	13.1	23.8	31	7.3	10	24.8
20.3	27.0	1	15.5	28	17.1	20.5	17	14.3	29	18.6	21.4	17	11.0	30	12.1	14.9	28	8.3	20	19.8	26.5	15	12.9	2	18.3	24.7	22	14.6	9	22.8
19.7	29.6	1	11.2	31	10.5	11.8	11	9.3	22	7.2	10.3	1	5.3	17	5.7	7.6	7	4.0	29	7.7	23.8	30	3.8	1	15.8	23.9	1	9.1	18	21.0
12.9	16.2	5	8.8	31	6.8	8.7	12	4.8	26	5.4	7.8	22	3.8	11	3.9	5.2	1	2.4	27	2.7	3.5	5	2.1	20	4.9	8.0	13	2.0	31	17.2
24.5	28.7	20	17.3	31	16.5	23.9	31	12.7	8	17.9	24.1	1	13.6	30																

TABLE No. 6.

Effect of Freezing on Strength of Louisville Cement Mortar; Cairo Bridge, 1887-1889.

Cement.	Fineness.		Proportions.		Tensile strength in lbs. per sq. in. at age of							
					Frozen.		28 Days.		3 Months.		6 Months.	
	Per Cent. Passing No. 50 Sieve.	Per Cent. Passing No. 100 Sieve.	Cement.	Sand.	No. of Tests.	Average Strength.	No. of Tests.	Average Strength.	No. of Tests.	Average Strength.	No. of Tests.	Average Strength.
Falls City Mills.	90.0	80.0	1	2	25	0	10	75.8	10	139.0	5	138.4

Note.—Fifty briquettes were made and allowed to set in the air under a damp cloth in test-room for twenty-four hours. Twenty-five were then placed in water till broken at ages given. The remaining twenty-five were removed from test-room and frozen during the night following; then placed in water at 70° Fah. When thawed eleven were broken; four broke on being removed from the pans the following night to refreeze. After second freezing and thawing the remaining ten were ound broken.

TABLE NO. 7.

The Effect of Salt on Strength of Cement Mortars. Cairo Bridge 1887-1889.

CEMENT.	Fineness.		Proportion by Volume.		Weights Ounces.			Tensile Strength in Pounds per square inch.				
	% Passing. No. 50 Sieve.	% Passing. No. 100 Sieve.	Cement.	Sand.	Cement.	Sand.	Water.	No. Salt.	Water 2% Salt.	Water 4% Salt.	Water 8% Salt.	Water 12% Salt.
Portland: Alsen's	99.2	87.0	1	2	3	8	1	200.9	212.8	223.1	215.2	244.9
Louisville: Falls City Mills	92.4	83.5	1	2	4	16	2½	175.5	179.4	171.7	145.9	156.4

Each result is the mean obtained from ten briquettes at the age of six months.

TABLE NO. 8.

Effect of Fine Grinding on Strength of Cement Mortars.

Cairo Bridge 1887–1889.

Cement.	Tensile Strength in Pounds per Square Inch at Age of Six Months.														
	Cement 100 % Fine. By Weight. Sifted Cement 10 parts. Screenings 0 "			Cement 90 % Fine. By Weight. Sifted Cement=9 Screenings =1			Cement 80 % Fine. By Weight. Sifted Cement = 8 Screenings = 2			Cement 70 % Fine. By Weight. Sifted Cement = 7 Screenings = 3			Cement 60 % Fine. By Weight. Sifted Cement = 6 Screenings = 4		
	By Volume.			By Volume.			By Volume.			By Volume.			By Volume.		
	Cem. 1 Sand 0	Cem. 1 Sand 1	Cem. 1 Sand 2	Cem. 1 Sand 0	Cem. 1 Sand 1	Cem. 1 Sand 2	Cem. 1 Sand 0	Cem. 1 Sand 1	Cem. 1 Sand 2	Cem. 1 Sand 0	Cem. 1 Sand 1	Cem. 1 Sand 2	Cem. 1 Sand 0	Cem. 1 Sand 1	Cem. 1 Sand 2
Louisville															
Falls City Mill	273.7	2 6.6	202.5	279.3	226.1	197.3	281.5	224.6	173.6	261.5	229.8	181.0	306.9	229 2	176.4
" " "	363.4	299.4	210.8	376.4	310.0	188.0	376.2	284.8	1 6.6	347.2	264.2	187.5	389.4	216.0	176.3
" " "	321.6	322.4	232.3	349.5	357.8	227.4	295.4	359.2	209.4	304.8	345.6	198.6	261.4	302.5	179.1
" " "			149.5			153.6			142.5			126.0			113.0
Mean	319.6	.82.8	198.8	335.1	297.9	191.6	317.7	289.5	180.5	304.5	279.9	173.3	3 9.2	249.2	161.2
Portland															
Alsen's	596.7	461.9	337.6	615.0	415.0	311.0	628.7	402.0	264.0	668.3	355.1	260.0	705.2	343.3	241.4
"	643.1	493.2	306.3	627.6	503.0	286.4	688.6	469.6	261.0	716.2	427.0	237.0	718.4	361.3	206.8
Mean	6 9.9	477.5	321.9	6 1.3	459.0	298.7	658.6	435.8	262.5	692.3	341.0	248.5	711.8	352.3	224.1

"Sifted Cement" is cement passing No. 100 sieve. "Screenings" is cement not passing.
Each result is the mean obtained from ten briquettes.

TABLE NO. 9.

EFFECT OF SETTING BETWEEN POROUS BEDS ON STRENGTH OF LOUISVILLE CEMENT MORTAR. CAIRO BRIDGE 1887-'89.

Cement.	Fineness.		Weights, ozs.			Proportions by Vol.		Tensile Strength at Age of 28 Days.	
	Per cent. Passing No. 50 Sieve.	Per cent. Passing No 100 Sieve.	Cement.	Sand.	Water.	Cement.	Sand.	When removed from molds allowed to set 24 hours between blotters under pressure; then placed in water for 27 days.	When removed from molds allowed to set 24 hours on a glass plate, under wet cloths in usual manner; then placed in water 27 days.
Louisville.................. Black Diamond,........	89.7	82.2	4	16	4½	1	2	20.7 pounds per sq. in.	7.4 pounds per sq. in.

Each result is the mean obtained from ten briquettes.

TABLE NO. 10.

TENSILE STRENGTH OF PORTLAND CEMENT MIXED WITH LIMESTONE SCREENINGS AND SAND. CAIRO BRIDGE, 1887-1889.

No. of Test.	Proportions by weight, ozs.					Proportion by volume.				Tensile Strength in Pounds per sq. in. at age of 7 days.
	Cement.	Sand.	Dust.	Stone.	Water.	Cement.	Sand.	Dust.	Stone and Dust Mixed.	
1	10	0	0	0	2	1	0	0	0	535.6
2	6	0	7	0	2	1	0	1	0	404.2
3	3	0	7	0	1½	1	0	2	0	274.8
4	6	0	2½	4½	2	1	0	0	1	412.4
5	3	0	2½	4½	1¼	1	0	0	2	347.0
6	3	3⅞	3½	0	1½	1	1	1	0	217.6
7	3	3⅞	1¼	2¼	1½	1	1	0	1	180.4
8	3	7¾	0	0	1	1	2	0	0	146.8
9	3	7¾	⅞	1½	1	1	2	0	⅔	135.0

"Stone" signifies stone screenings passing No. 6 sieve and held on No. 20. "Dust" signifies stone screenings passing No. 20 sieve. "Stone and Dust Mixed" signifies stone screenings passing No. 6 sieve. Results of tests No. 1-7 are the means of (5) five briquettes. Results of tests No. 8-9 are the means of (10) ten briquettes.

TABLE NO. II.

TENSILE STRENGTH OF NATURAL CEMENT MORTARS: TESTS MADE IN ONE SERIES. CAIRO BRIDGE 1887–89.

CEMENT.	FINENESS.		TENSILE STRENGTH IN POUNDS PER SQUARE INCH AT AGE OF														
			SEVEN DAYS.			TWENTY-EIGHT DAYS.			THREE MONTHS.			SIX MONTHS.			ONE YEAR.		
			Proportions by Volume			Proportions by Volume			Proportions by Volume			Proportions by Volume			Proportions by Volume		
	% Passing No. 50 Sieve.	% Passing No. 100 Sieve.	Cem. 1. Sand 0.	Cem. 1. Sand 1.	Cem. 1. Sand 2.	Cem. 1. Sand 0.	Cem. 1. Sand 1.	Cem. 1. Sand 2.	Cem. 1. Sand 0.	Cem. 1. Sand 1.	Cem. 1. Sand 2.	Cem. 1. Sand 0.	Cem. 1. Sand 1.	Cem. 1. Sand 2.	Cem. 1. Sand 0.	Cem. 1, Sand 1.	Cem. 1. Sand 2.
Louisville.																	
Fall City Mill......	90.0	79.5	83.3	35.0	4.0	160.9	82.6	40.7	195.4	200.7	123.8	208.7	258.1	176.1	311.9	257.8	142.8
" " "......	92.4	83.5	129.2	62.8	14.2	157.7	125.8	85.9	240.1	246.0	210.2	270.0	250.9	160.6	393.7	191.6	171.9
" " "......	87.0	77.8	138.4	47.9	2.1	204.3	150.4	32.7	259.7	335.1	135.6	361.3	302.0	171.1	407.8	335.4	171.9
Mean...........	89.8	80.3	117.0	48.6	6.8	174.3	119.6	53.1	231.7	260.6	156.5	280.0	270.3	169.3	371.1	261.6	162.2
Black Diamond...	92.5	80.7	94.7	16.9	3.6	210.1	78.0	65.0	237.6	172.6	164.4	261.8	209.5	148.8	260.4	192.9	140.3
" "...	89.0	80.6	108.0	45.3	2.6	137.3	102.9	48.5	289.4	219.5	142.2	383.9	194.3	169.1	459.5	193.3	154.1
" "...	86.9	79.3	113.1	17.2	2.6	201.9	38.3	18.8	305.2	251.4	115.1	366.7	355.0	152.7	421.8	344.2	138.2
Mean...........	89.5	80.2	105.3	26.5	2.9	183.1	73.1	44.1	277.4	214.5	140.6	337.5	252.9	156.9	380.6	243.5	144.2
Queen City Mill..	90.3	80.6	121.8	58.8	37.4	212.4	98.3	88.1	228.2	154.7	168.7	314.5	173.0	142.0	342.4	121.2	110.0
" " "..	85.7	72.3	210.3	104.7	22.0	223.5	170.3	107.8	303.6	217.1	147.1	298.5	219.4	97.7	344.8	200.1	122.3
" " "..	80.6	70.0	165.4			273.1			285.1			303.2			402.0		
" " "..	89.6	78.5		29.3			128.9			228.8			230.9			170.4	
" " "..	88.9	77.2			31.7			106.3			192.2			152.9			144.9
Mean...........	87.0	75.7	165.8	64.3	30.4	236.3	132.5	100.7	272.3	200.2	169.3	305.4	207.8	130.9	363.1	163.9	125.7
Silver Creek Mill.	90.7	79.6	111.9	45.2	18.1	184.6	103.6	45.7	222.0	197.8	117.5	262.6	178.4	132.1	320.4	135.4	90.4
Mean of 4 Brands.	88.6	78.3	127.6	46.3	13.8	1[illegible]6.6	107.9	64.0	2[illegible]6.6	222.4	151.7	300.1	237.1	150.3	366.5	214.2	138.7
Utica.																	
Clark Brand......	84.2	75.7	57.2	37.2	6.6	70.8	63.3	34.8	138.1	283.1	184.4	233.3	317.6	170.7	233.3	240.4	158.5
Black Ball Brand.	73.0	69.2	111.4	74.0	38.3	203.6	133.6	91.1	276.5	164.0	107.0	282.5	168.4	109.2	299.6	200.0	135.6
Mean...........	78.6	65.0	84.3	55.6	22.5	137.2	98.5	62.9	207.3	223.5	145.7	257.9	243.0	139.9	266.4	220.2	147.1
Milwaukee..........	91.4	79.2	56.8	21.8	2.9	78.4	71.1	11.0	137.9	210.4	178.1	290.9	233.1	154.2	258.5	192.1	162.2
"	86.4	72.4	62.0	14.6	7.1	111.9	76.9	51.4	171.4	283.2	160.3	216.0	242.2	164.2	254.8	256.8	180.9
"	81.3	67.9	62.0	9.0	0.0*	104.7	35.2	1.6	265.6	249.6	149.2	298.2	242.0	91.4†	274.5	224.5	146.6
Mean...........	86.4	73.2	60.3	15.1	3.3	98.3	61.1	21.3	191.6	247.7	162.5	268.4	239.1	136.6	262.6	224.5	163.2

*Broke by weight of Clips. †Separate Briquettes vary from 0 to 193. Each result is the Mean obtained from ten (10) Briquettes.

TABLE No. 12.

TENSILE STRENGTH OF PORTLAND CEMENT MORTARS. TESTS MADE IN ONE SERIES. CAIRO BRIDGE, 1887-1889.

Cem'nt.	Fineness. Per Cent. Passing Noo. 50 Sieve.	Fineness. Per Cent. Passing No. 100 Sieve.	7 Days. Cem. 1 Sand 0	7 Days. Cem. 1 Sand 1	7 Days. Cem. 1 Sand 2	28 Days. Cem. 1 Sand 0	28 Days. Cem. 1 Sand 1	28 Days. Cem. 1 Sand 2	3 Months. Cem. 1 Sand 0	3 Months. Cem. 1 Sand 1	3 Months. Cem. 1 Sand 2	6 Months. Cem. 1 Sand 0	6 Months. Cem. 1 Sand 1	6 Months. Cem. 1 Sand 2	1 Year. Cem. 1 Sand 0	1 Year. Cem. 1 Sand 1	1 Year. Cem. 1 Sand 2
			Tensile Strength in Pounds Per Square inch at age of — Proportions by Volumes.			Proportions by Volumes.			Proportions by Volumes.			Proportions by Volumes.			Proportions by Volumes.		
Alsen's.	98.8	82.8	537.7	263.2	161.2	579.4	289.1	199.1	692.6	315.4	230.3	616.6	330.4	*228.6	655.3	375.8	201.9
Alsen's.	98.9	84.9	537.0	355.2	194.6	546.4	377.3	224.0	667.4	477.5	242.9	657.8	494.4	?285.8	711.8	473.7	283.7
Alsen's.	98.9	84.9	575.4	......	......	590.4	......	......	655.8	......	......	657.7	......	......	699.8	......	......
Mean . .	98.9	84.2	550.0	309.2	177.9	572.1	333.2	211.6	671.9	396.4	236.6	644.0	412.4	257.2	688.9	424.8	242.8
Fewer. .	99.0	89.0	485.5	208.2	104.1	582.4	226.0	138.9	688.1	283.2	208.5	628.2	387.2	212.1	578.4	348.2	203.3
Burham	94.0	76.3	470.5	198.4	95.0	561.8	214.4	108.6	611.2	272.6	161.1	586.6	297.5	180.0	597.5	334.6	171.6

*9 months old. ?4 months old.

Each result is the mean obtained from the ten (10) briquettes.

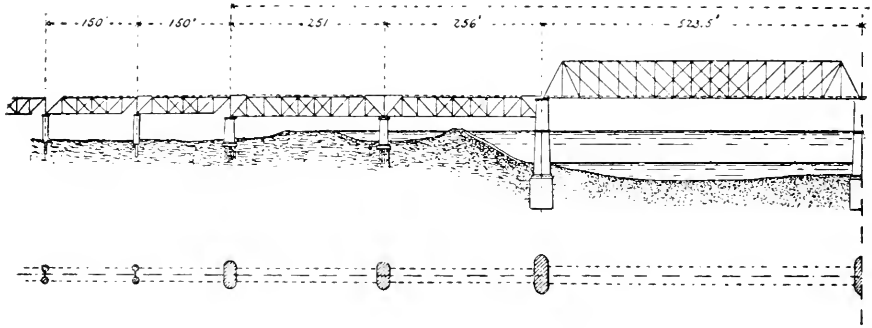
TABLE NO. 13.

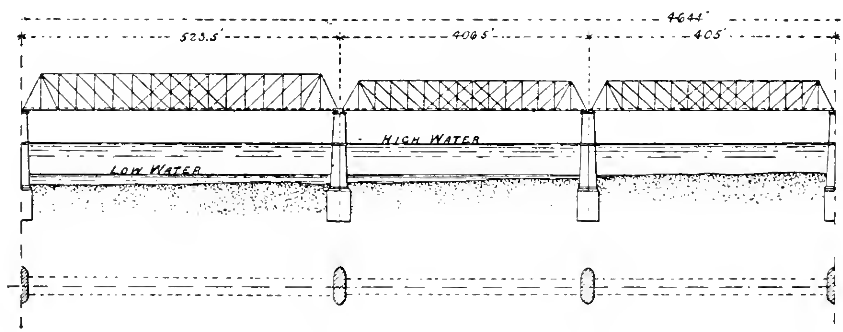
Quantities of Materials used in Masonry; Cairo Bridge 1887–1889.

PIER.	Cubic Yds. of Masonry Measured in Pier.			Per Cent. of Total.		Barrels of Cement Used.			Barrels of Cement Used.			Cubic Yds. of Sand Used.		
	Of Face Stone.	Of Backing.	Of Total.	Face Stone.	Backing.	Portland.	Louisville.	Total.	per cu. yd. of Face Stone.	per cu. yd. of Backing.	per cu. yd. of Masonry.	per cu. yd. of Face Stone.	per cu. yd. of Backing.	per cu. yd. of Masonry.
I	278.3	49.4	327.7	84.9	15.1	66	107	173	0.24	2.17	0.53	0.07	0.60	0.07
II	1547.3	1032.4	2579.7	60.0	40.0	315	698	1013	.20	0.68	.39	.06	.19	.11
III	1579.4	1102.8	2682.2	58.9	41.1	307	770	1077	.19	.70	.40	.05	.19	.11
IV	1659.1	1212.6	2871.7	57.8	42.2	322	825	1147	.19	.69	.40	.05	.19	.11
V	1658.5	1216.7	2875.2	57.7	42.3	315	826	1141	.19	.69	.40	.05	.19	.11
VI	1663.0	1221.6	2884.6	57.7	42.3	332	793	1125	.20	.65	.39	.05	.18	.11
VII	1673.1	1211.2	2884.3	58.0	42.0	323	913	1236	.19	.75	.43	.05	.21	.12
VIII	1661.2	1230.4	2891.6	57.4	42.6	347	956	1303	.20	.78	.45	.06	.22	.13
IX	1974.3	1822.3	3796.6	52.0	48.0	400	1108	1508	.20	.61	.40	.06	.17	.11
X	2034.1	1785.8	3819.9	53.3	46.7	430	1070	1502	.18	.64	.39	.05	.18	.11
XI	2085.0	1716.5	3801.5	54.8	45.2	393	1168	1561	.17	.70	.41	.05	.20	.12
XII	371.0	76.1	447.1	83.0	17.0	71	73	144	.21	.96	.32	.05	.27	.09
XIII	339.7	63.8	403.5	84.2	15.8	65	70	135	.19	1.13	.33	.05	.32	.09
Total	18524.0	13741.6	32265.6			3686	9377	13065	0.192	0.693	0.405	0.053	0.194	1.13

CAIRO

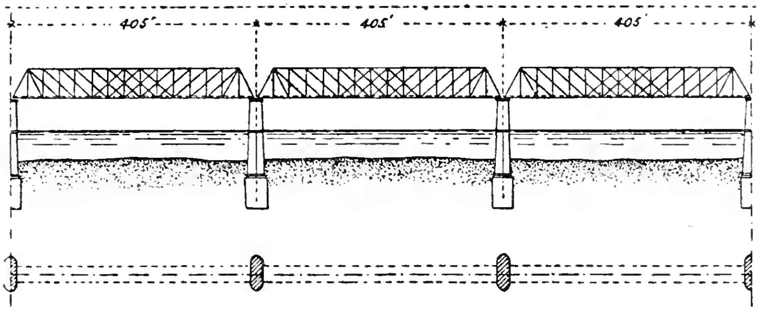
ELEVATION





BRIDGE. PLATE I.

AND PLAN.



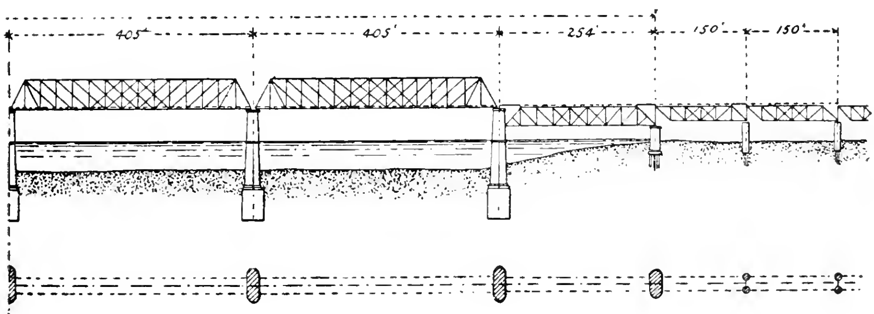
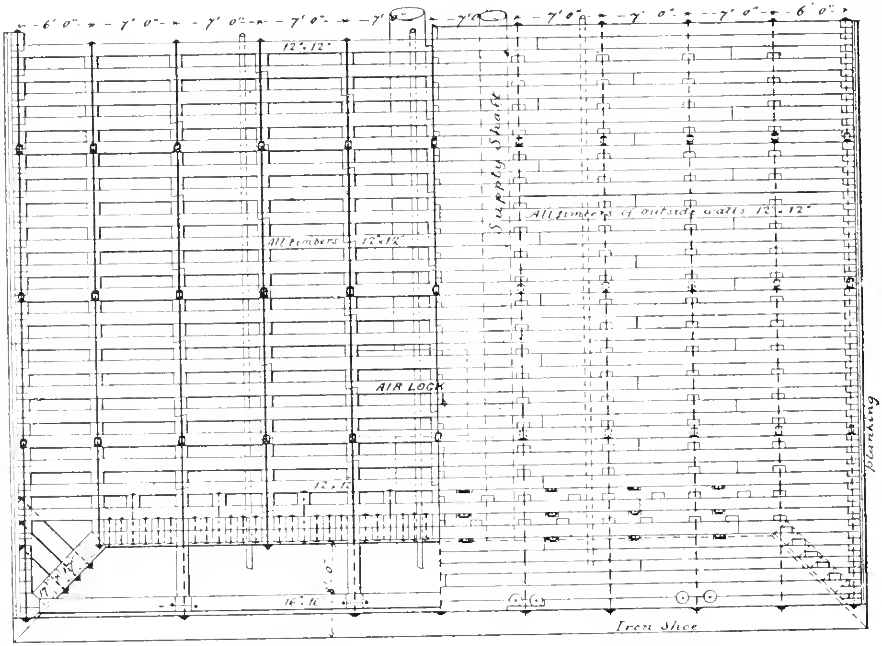
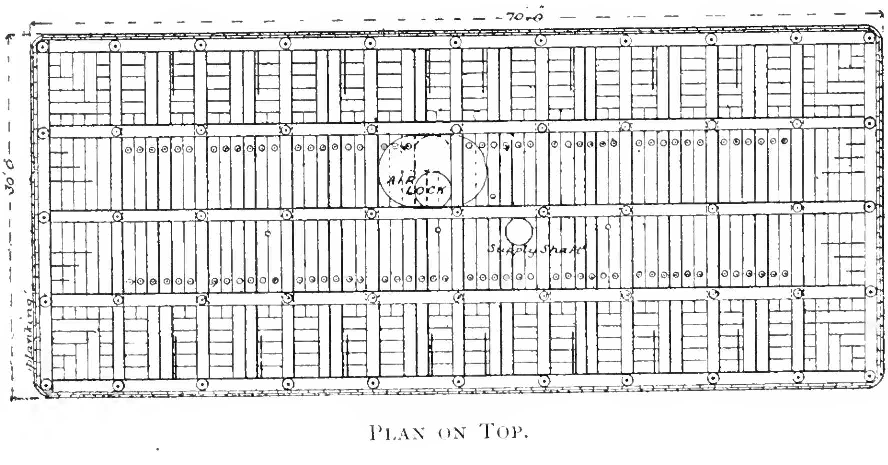


PLATE II.



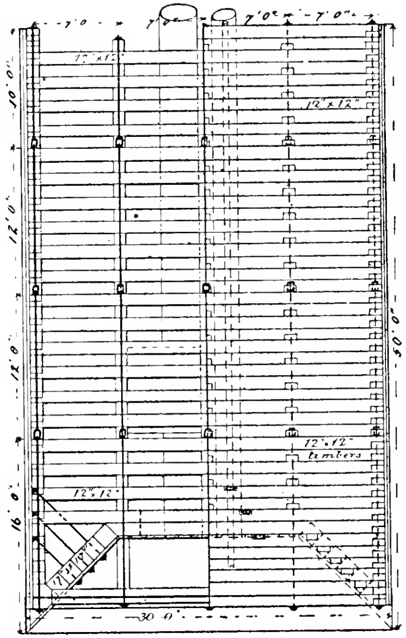
LONGITUDINAL SECTION AT CENTRE.

SIDE ELEVATION UNDER PLANKING.



PLAN ON TOP.

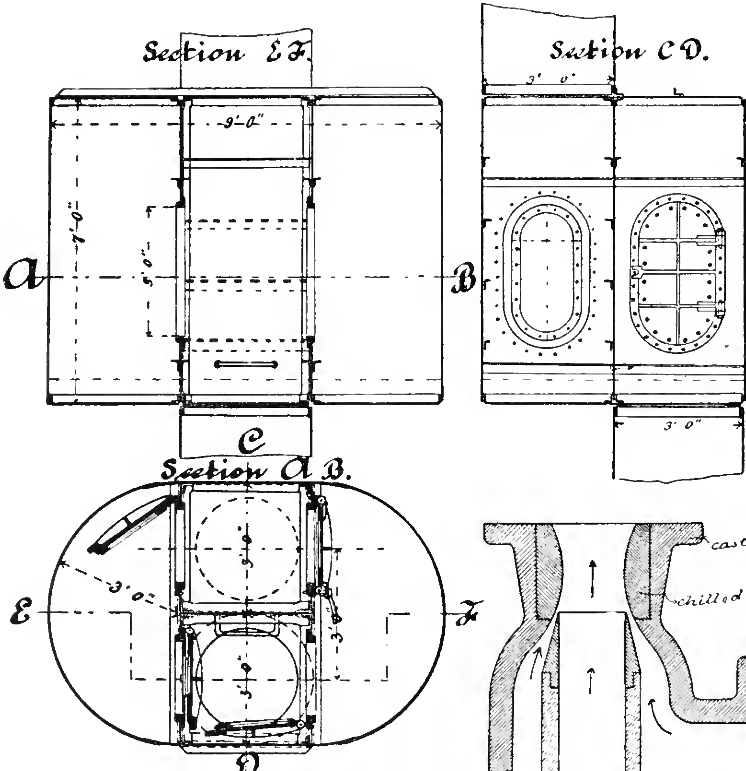
PLATE II.—CONTINUED.



CROSS SECTION AT CENTRE. END ELEVATION UNDER PLANKING.

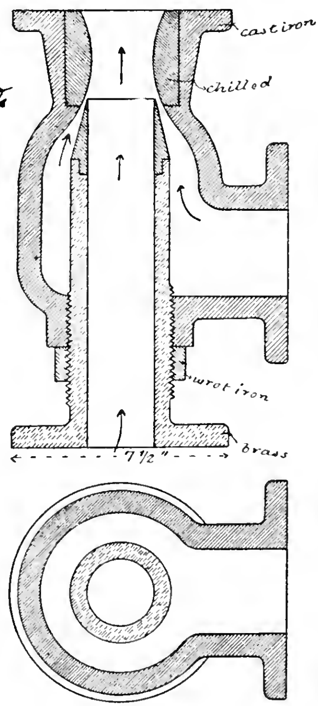
CAISSON AND CRIB WORK.

30 × 70 × 50 FEET.



Air Lock

PLATE III.



Sand Pump

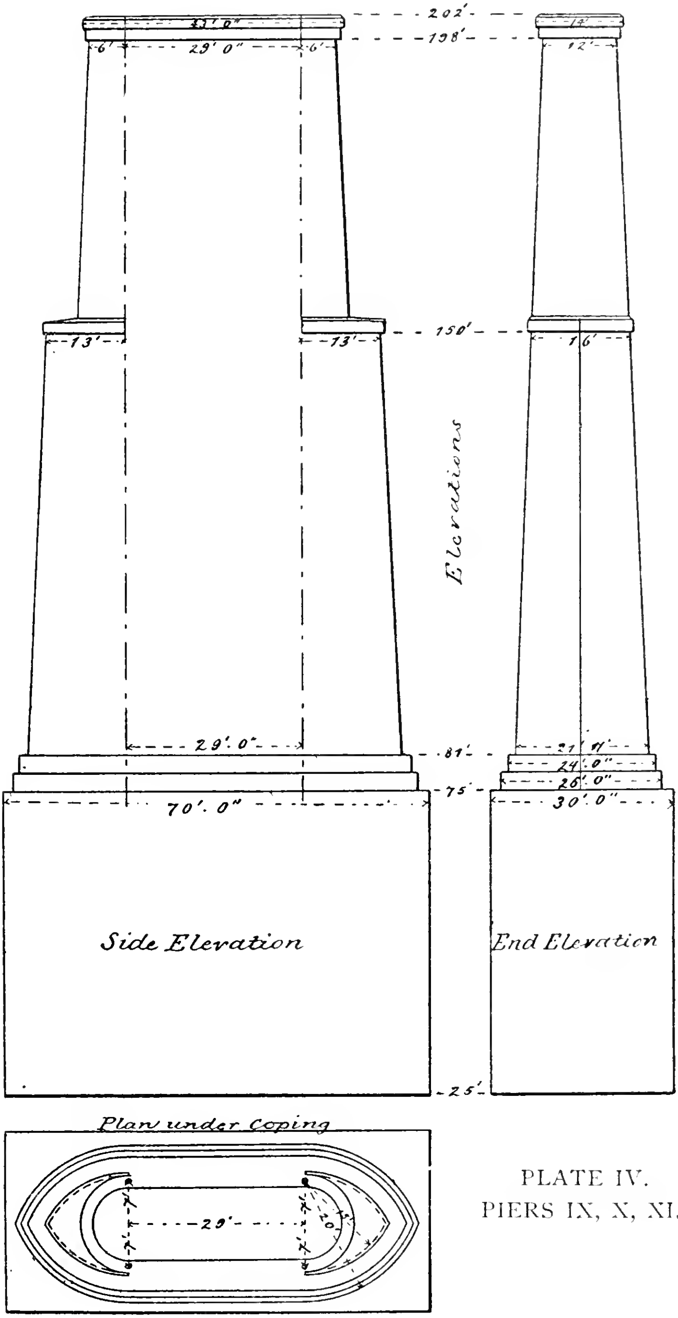


PLATE IV.
PIERS IX, X, XI.

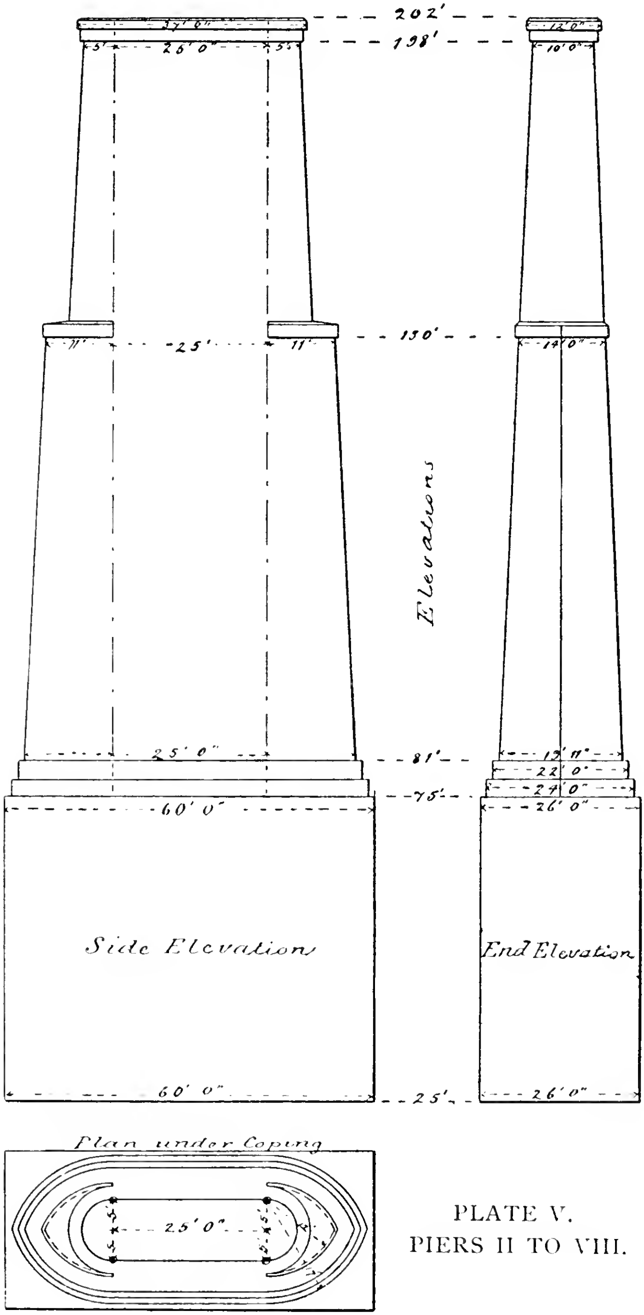
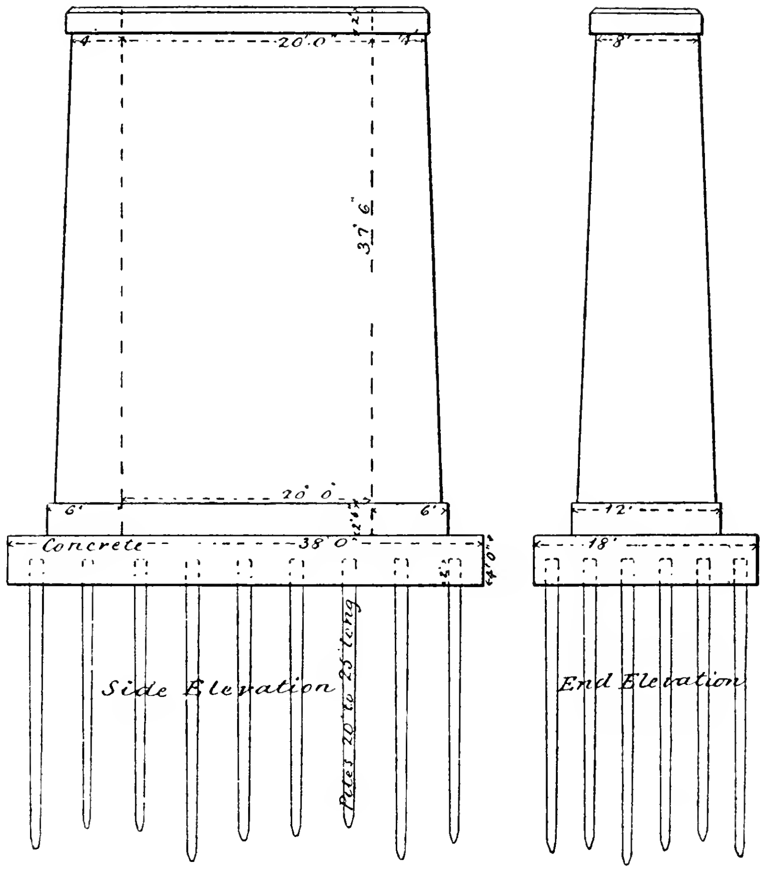


PLATE V.
PIERS II TO VIII.



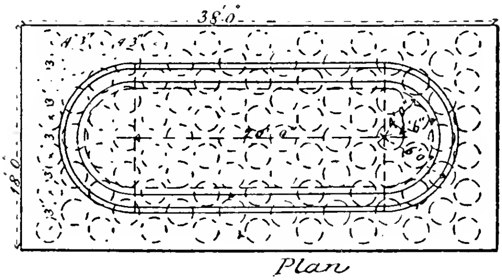


PLATE VI.

PIER XII.

Specifications for Bridge Across the Ohio River at Cairo, Ill.

GENERAL DESCRIPTION.

The bridge will consist of two channel spans, seven river spans and three approach spans. There will be ten masonry piers in the river, founded on pneumatic caissons, these ten piers supporting the nine channel and river spans; and three smaller piers founded on piles, supporting the approach spans.

The sub-structure of the bridge will be understood to include these thirteen piers, both masonry and foundations.

The superstructure will include the twelve spans above named.

Full detailed plans of both sub-structure and superstructure will be furnished by the engineer of the bridge.

The work shall be built in all respects according to the plans. The contractors, however, will be expected to verify the correctness of the plans and will be required to make any changes in the work which are necessitated by errors in these plans without extra charge, where such errors can be discovered by inspection of the plans.

SUB-STRUCTURE.

The three piers next to the Illinois shore, which support the two main channel spans, will finish 12 feet thick, and 29 feet long between shoulders and 41 feet long over all under the coping. The other seven river piers will measure 10 feet thick and 25 feet long between shoulders and 35 feet long over all under the coping.

The masonry of the ten channel and river piers shall begin 25 feet below low water, or at elevation 75 above the assumed datum.

The masonry of the shore piers shall begin 10 feet below the natural surface of the ground.

The pneumatic foundations of the river piers shall be sunk 75 feet below low water or to an elevation 25 feet above datum, unless otherwise specially directed.

PNEUMATIC FOUNDATIONS.

The pneumatic caissons for the three channel piers will be 30′ wide and 70′ long. Those of the seven river piers 26′ wide and 60′ long.

The caissons will be surmounted by a timber crib work which shall make the total height from cutting edge to top of crib work 50′, the sides being vertical and the top of the crib finished of the same dimensions as the caisson.

The caissons and crib work shall be built of thoroughly sound yellow pine timber or such other timber as may be approved by the Engineer of the bridge, and shall be planked on the outside with two thicknesses of 3″ oak plank, the inner thickness being put at an angle of 45°. The timber work shall be accurately and closely framed, the timbers being sized so as to secure immediate contact throughout and the inner course of plank being planed to uniform thickness so as to secure an exact fit for the outer course.

The timbers shall be bolted together with long rods and with drift bolts as shown on the plans.

The cutting edge of the caissons shall be of iron and of the form shown on the plan. An iron working shaft shall be built into the caisson and crib work for a height of 20 feet above the roof of the working chamber which distance may include the shell of the air lock.

A supply shaft 24″ in diameter shall also be built into the caisson, crib work and masonry. One 4″ air pipe, one 5″ water pipe and two 4″ discharge pipes shall also be built into the caisson, crib work and masonry.

The space above the working chamber and within the outer walls of the caisson and crib work shall be filled with concrete. The concrete within 2′ of the top of the roof of the working chamber shall be formed of Portland cement and sand, three parts of sand to one part of cement, into which sound stone may be rammed after it is put in position. The upper one foot of the concrete shall be formed in the same way. The remainder of the concrete shall be made of Louisville cement, sand and stone, two parts of sand to one of cement, and not over 60 per cent. of the whole volume in broken stone, the amount of cement not to exceed two barrels per cubic yard.

In Portland cement the sand and cement shall be mixed together dry, then run through a satisfactory machine mixer. The mass of concrete shall always be thoroughly rammed after being put in position. The Louisville cement concrete shall be worked in a mixer approved by the Engineer.

The caissons shall be sunk to the height specified above and shown on plans, unless otherwise specially directed by the Engineer, and shall not vary more than 15″ from correct position. The sand shall be excavated by the method employed at the Rulo and Omaha bridges, unless some other plan is approved specially, when the required depth is obtained, the caissons shall be filled with concrete, the lower two feet of concrete, reaching to the shoulder of the cutting edge and to the cross-beams, shall be formed of Portland cement and sand, three of sand to one of cement. The remainder of the filling may be of Louisville cement, sand and stone, in the proportion above mentioned. The working shaft and supply shaft and pipes shall not be filled but shall be closed at the ends with iron or wooden bulkheads.

PILE FOUNDATIONS.

The piles shall be arranged according to detailed plans to be furnished by the engineer. They shall be straight and of good, sound, white or burr oak or cypress or other hard wood that may be driven to refusal without splitting: they shall be at least 11″ in diameter at the small end.

They shall be driven in a pit excavated about 12′ deep and so as not to go more than one-half inch at the last blow of a hammer weighing 3,000 lbs., and falling 25 feet. They shall be cut off level and finished clear of splinters.

Concrete made of Portland cement and mixed as prescribed elsewhere in these specifications, shall be placed between the piles and shall be well rammed and shall extend at least two feet below the heads of the piles and two feet above them and shall then be perfectly leveled off.

On this concrete foundation, when it has become well set, shall be

built masonry piers according to the general plans now furnished and more detailed plans to be furnished by the Engineer in charge, after which the pits shall be refilled with earth well rammed.

MASONRY.

The stone must be strong, compact and of uniform quality and appearance and free from any defect, that in the judgment of the Engineer may impair its strength or durability.

The stone from the quarries in Bedford, Indiana, will be acceptable stone for dimension work. The Engineer may authorize the acceptance of other stone, which, in his judgment, is equal in quality and similar in appearance to the Bedford stone. The corner stone in each course of the up-stream nose of the ten river piers shall be of granite.

There shall be no courses less than 15″ in thickness and no course shall be thicker than the one immediately beneath it.

The joints shall be broken at least 15″; each bed of every stone shall be at least 1½ times the thickness of the course in both directions and there shall be none less than 30″, and no stone shall have an overhanging top bed.

The stretchers shall not be less than four (4) feet, nor more than seven (7) feet long. Stretchers of the same width shall not be placed together vertically.

The headers shall be from five (5) to six (6) feet long; every second or third stone in each course must be a header, and there shall be at least five headers in each course between the shoulders. They must hold 75 per cent. size from face to back.

The joints to the face stones shall be cut 12″ back from the face. The horizontal joints shall average ½″ and shall never be less than ⅜″.

No leveler shall be put under a stone to bring it up to the proper level.

No hammering shall be allowed after the course is set; if any inequalities occur, they must be carefully pointed off.

All stones, whether face, coping or backing, shall be laid with the natural bed horizontal and in full flush beds of mortar, mixed fresh as required for work. All stone must be carefully cleaned and moistened before being laid, and no mortar shall be laid on any stone already set, until the latter has been thoroughly cleaned and wet.

Each course must be completed and the mortar in the vertical joints well rammed before the next one is begun.

The face work shall be in Ashlar (rock face), but no projection greater than 3″ will be allowed, nor will any hollow stone.

The up-stream starlings below high water, shall be fine pointed to ½″.

The top coping and the coping of the projecting starlings shall be bush hammered throughout.

The top coping shall have a wash 12″ wide and 6″ high. The coping shall be made according to special plans, so as to give proper bearing for the bridge seats.

There shall be a draft line of 3″ on the corners of the piers and along the lower edge of the belting course under the coping.

The face stones of every course of the up stream starlings between

high and low water shall be doweled into those of the course below with round dowels of $1\frac{3}{8}''$ iron extending 6″ into each course; the dowels shall be placed from 8″ to 12″ back from the face, and 6″ on each side of every joint. The stones of the upper course shall be drilled through before setting, after which the drill holes shall be extended 6″ into the lower course; a small quantity of mortar shall then be put into the hole; the dowel dropped in and driven home and the hole filled with mortar and rammed. The three courses below the coping shall have the joints bonded with cramps of $\frac{7}{8}''$ round iron, 20″ long between shoulders, the ends being sunk 3″ into each stone.

The dimension stone shall be laid in Portland cement mortar of two parts of sand and one part of cement. The backing shall be laid in mortar of American cement of two parts of sand and one part of cement.

The Portland cement shall be an imported cement, equal in quality to O. F. Alsen & Sons best quality, and the American cement shall be equal to the best grades of Louisville cement.

When masonry is laid up in freezing weather, the backing shall be laid in Portland cement three parts of sand and one part of cement, and such other precautions taken against freezing as the Engineer may direct.

The joints of the face stones shall be picked out and pointed in mild water, with two parts of sand and one part of Portland cement which shall be driven with a calking iron.

JAMES S. OVIATT.

A MEMOIR.

By JOHN WHITELAW, WALTER P. RICE AND SAMUEL J. BAKER—A COMMITTEE OF THE CIVIL ENGINEERS' CLUB OF CLEVELAND.

[Read May 13, 1890.]

James S. Oviatt, a member and past officer of this Club, died March 13, 1890. He was the only son of Schuyler R. Oviatt, and was born in Richfield, Summit county, Ohio, April 5, 1845. He entered Western Reserve College in 1863 and graduated in 1867. The following year he was principal of the Kinsman, Ohio, Academy. In January, 1869, he entered the office of the City Civil Engineer of Cleveland as an assistant, where he remained until the time of his death. His work for the first few years in the office was upon miscellaneous city improvements, surveys, etc., and about the year 1873, he was assigned to the sewerage department, and served as assistant to the engineer in charge of the same until 1878, when he was himself placed in charge of the department, a position he continued to hold up to the time of his death. During this period the planning and construction of all city sewers were practically under his direction, though subject to the approval of the City Civil Engineer, and it can be truly said that his work has been characterized by sound judgment, based upon a thorough knowledge of the topography and sewerage needs of the city. His knowledge of the laws bearing upon sewerage was also quite extensive, and of great value in the preparation of all official papers for sewerage and assessment.

His death occurred quite unexpectedly. In the early part of last winter he injured his knee in endeavoring to board a motor street car. This injury caused a lameness which confined him to his house, where he also suffered from an attack of la grippe. While recovering from this he received a severe fall in his house, while still lame, and probably from weakness due to illness and the shock so incurred, he was seized with an affection of the heart from which he died quite suddenly.

Personally Mr. Oviatt was of an extremely amiable disposition, and was noted for his good nature and kindly manners, and was greatly beloved by his intimate friends. In his official position he was ever accommodating and pleasant to all who had dealings with him. By his death the city has been deprived of the services of an able, upright, and obliging employe, and this fact was attested by appropriate resolutions of respect adopted by a meeting of all the city officers and by the city council.

Mr. Oviatt was one of the founders of the Civil Engineers' Club of Cleveland and served as its Treasurer from April 1881, to March, 1883, and as Corresponding Secretary from March, 1886, to March, 1887.

In 1876 he was married to Miss Lucy Lindsay of this city, who, with two daughters aged 5 and 12 years, survives him.

ASSOCIATION OF ENGINEERING SOCIETIES.

PROCEEDINGS.

ENGINEERS' CLUB OF KANSAS CITY.

MAY 12, 1890.—A regular meeting was held in the Club Room at 8 p. m., F. E. Sickels in the chair, K. Allen, Secretary. There were present eleven members.

Minutes of the last regular meeting, and of that of the Executive Committee were read and approved.

Mr. A. J. Mason read, for the Committee on Affiliation of Engineering Societies abstracts from a communication from Prof. J. B. Johnson, of St. Louis, proposing a federation of the leading Engineering Societies (including the "Association"). Mr. Mason also presented a brief verbal report for the Committee on Affiliation, the sentiment of which was adverse to the connection of the local societies with the American Society.

On motion of K. Allen, the report was accepted and the committee requested to continue.

Mr. Allen thought the field work of the local societies was quite distinct from that of the American Society, and that joint publications would be unnecessarily expensive and cumbersome for many members.

Messrs. Filley and Stone were opposed to the proposed "Federation" having a local habitation, while Messrs. Sickels and Mason held the opposite view, and thought that by selecting the city of Washington especial advantages would be attained without incurring hostility.

On canvas of ballots A. Clifford Thomas was declared elected as member.

The Secretary read for the author, Robert M. Sheridan, a paper on "The Evolution of the Elevator."

Beginning with the year 1855 the paper traced the growth of the elevator engine from the osciliating cylinder reversing engines which marked the first step in the development of this branch of engineering, to the perfected steam worm-geared passenger elevator engine in use at the present time. A summary of the various steps embracing the changes in engines of this class was presented. The vertical cylinder hydraulic machine was described and contrasted with the perfected horizontal cylinder elevator and its improvements. The workings and advantages of the lever operating device in its connection with the auxiliary valve, together with the pronounced usefulness of the independent automatic stop valve were explained. The description of the principle of the centrifugal governor attached to the car as a safety device for arresting the car's motion was given and accompanied by a general statement concerning the present requisites for elevator service, covering the point of absolute regulation at the highest speeds by the use of the improvements mentioned. The travel of the tower elevator in the Chicago Auditorium building, passing through a distance 220 feet at a speed of about seven miles per hour, or 600 feet per minute, was cited as of a case in point covering the various demands upon elevator service at the present time. The future of the work, judging by the past, insures the elevator's evolution along the lines now set, keeping pace with the demand for buildings that tower nearer the sky year by year.

Adjourned. KENNETH ALLEN, Secretary.

June 9, 1890.—A regular meeting was held in the Club Room at 8 P. M., Vice-President Mason in the chair, Kenneth Allen, Secretary. There were present ten members and one visitor.

Minutes of the last regular and Executive Committee meetings were read and approved.

A letter from the President, tendering his resignation on account of proposed absence, was read, but it was voted, on a motion of Mr. Stone, that the Secretary ask him to remain in office until the annual election of officers.

After a general discussion on Gas Engines, it was voted, on motion of Mr. Talmage, that the chair appoint a committee to make all necessary arrangements for the annual excursion. Messrs. Goldmark, Taylor and Talmage were appointed.

On account of the unavoidable absence of Mr. Gillham, it was decided to invite him to present his talk on the "City of Paris" accident at a special meeting to be announced.

Adjourned. Kenneth Allen, Secretary.

CIVIL ENGINEERS' CLUB OF CLEVELAND.

Regular Meeting, May 13, 1890.—Meeting called to order at 8 p. m., President William H. Searles in the chair; 20 members present. Owing to the absence of the Secretary, reading of the minutes of the last meeting was dispensed with.

The Executive Board reported favorably upon the application of the following gentlemen: For active membership, Edward P. Roberts, William H. Dunn, James C. Hallsted, John H. Hilton, William F. Biggar, and for Associate membership Joseph Daniels, Thomas M. Irvine, and William L. Otis.

The resignation of Mr. C. O. Palmer, as Secretary of the Club, rendered necessary by his business arrangements, was read and accepted, and a vote of thanks tendered him for his services. The President announced that the office of Secretary would be filled by election at the next meeting, and that the names of E. H. Jones and A. H. Porter were suggested by the Executive Board for that purpose.

On motion of Mr. Mordecai: the election was ordered to be by letter ballot.

A memoir of the late James S. Oviatt, was read by Mr. John Whitelaw, Chairman of the Committee appointed at last meeting, and was ordered spread upon the minutes and printed in the Journal.

The financial report of the Banquet Committee was read by Mr. Mordecai, showing a balance of accounts. The report of the committee on affiliation with the American Society of Civil Engineers was presented by Mr. Mordecai, chairman, including a letter from Mr. J. F. Holloway. Report was adopted and Committee requested to attend the conference of committees in New York in June next, if possible Mr. Thompson reported that he had procured the carved stone containing the name of Charles Latimer, and placed it in the Club room, and now presented the same to the Club. A vote of thanks was tendered Mr. Thompson for this memento.

A letter was read from the Superintendent of the Smithsonian Institution, inviting exchange of publications. Referred to the Executive Board.

The paper of the evening, entitled: "Experience in the Construction of Gas Holder-Tanks," was read by Mr. G. A. Hyde, and followed by a general discussion. The paper cited the difficulties of founding large tanks on a hill side composed of alternate layers of quick-sand and clay; one of the early tanks has shown some disturbance and is to be emptied for examination. The discussion was upon the soils in and about Cleveland, and on various methods adopted in laying foundations.

The President announced that at the June meeting Dr. H. Poole would present a paper entitled "Ferroid," a new artificial stone.

Adjourned. S. J. Baker,
Corresponding Secretary.

REGULAR MEETING, TUESDAY, JUNE 10, 1890.—Meeting called to order at 8 o'clock p. m., President Searles in the chair—twenty-eight members and two visitors present. Minutes of the previous meetings of April and May were read and approved.

The President appointed Messrs. Osborn and Bowler tellers to canvass the letter ballots for Secretary, and also for new members.

The Executive Board reported favorably upon the application of James Morris White for active membership.

Mr. Mordecai, Chairman of the Committee on Affiliation with the American Society of Civil Engineers, reported that he had communicated with Mr. Holloway, and requested him to represent the Club at the coming conference of Engineering Societies in New York.

A letter was read from Mr. Warner, Chairman of the Committee on Rooms, stating that the contemplated arrangements had not yet been effected.

The President announced the receipt of several books and pamphlets from different sources, also a framed lithograph of the Lick telescope, from the firm of Warner & Swasey.

A letter was read from the Engineer's Club of St Louis, accompanying a printed statement of the views of that Club on affiliation with the American Society. Referred to the Committee on Affiliation.

A letter to the President from Dr. R. W. Raymond, Secretary of the American Institute of Mining Engineers, requesting him to represent the Club at the Autumn Convention, was read, and some announcements were made regarding the expected visit to this country of the Iron and Steel Institute of Great Britain.

On motion of Mr. C. G. Force, the Club voted to hold a picnic at Rocky River in the latter part of July. Prof. Howe moved that a committee of five on picnic be appointed by the Chair. Carried.

The Chair appointed as follows: C. G. Force, Prof. Chas. S. Howe, G. W. Vaughan, Hiram Kimball and George E. Hartnell.

On motion of Mr. Force the committee was empowered to add to their number, from members of the Club, and also from among their families.

The tellers made their report, which was read and resulted in the election of Albert H. Porter as Secretary. The following gentlemen were elected Associate members: Joseph Daniels, Thomas M. Irvine and William L. Otis, and the following gentlemen were elected active members: Edward P. Roberts, James C. Hallsted, William H. Dunn, John H. Hilton, and William F. Biggar.

The Club then listened to a paper by Dr. Herman Poole, entitled: "Ferroid—A New Artificial Stone," which was followed by discussion.

Prof. Chas. S. Howe then read a paper on the Almucanter, a new instrument for field astronomy, greatly simplifying observations and calculations for time and latitude, and resulting in a degree of accuracy scarcely excelled by the most elaborate instruments on solid foundations. The paper was illustrated by a large drawing of the instrument, prepared by Prof. Saunders, member of the Club. After an interesting discussion of the subject, the Club adjourned. S. J. BAKER,

Corresponding Secretary.

ENGINEERS' CLUB OF ST. LOUIS.

327TH MEETING, MAY 7, 1890.—The meeting was called to order at 8:15 P. M., in the rooms of the Elks' Club, President Nipher in the chair; thirty-nine members and four visitors present. The minutes of the 326th meeting were read and approved. The executive committee reported the doings of its 90th and 91st meetings, announcing that the proposed celebration of the twenty-first anniversary would be held on the evening of the 1[illegible]th inst.

Prof. Arthur T. Woods, of Champaign, Ill., then addressed the club on "Com-

pound Locomotives." He distributed blue prints showing characteristic indicator cards, and also a tabulated statement of dimensions of certain standard types of compound locomotives. Of 500 now in operation, but a small number were in use in the United States. The number was rapidly increasing. He devoted some time to the history of the compound locomotive, explaining the advantages of multiple cylinder engines, and the characteristic features of the most prominent types. The most important requisites were simplicity and large power available for starting. He stated that the economy in fuel over single cylinder engines was found to vary from 13 to 24 per cent., and that the average of a large number of tests extending over considerable length of time, showed a saving of 18½ per cent. Another important advantage was that it was not necessary to force the boiler, it being therefore possible to secure better combustion. It was necessary that the locomotive be designed particularly for the work in hand, in order to secure the best results. In the writer's opinion, the compound locomotive has come to stay. Messrs. Bryan, Johnson and Nipher took part in the discussion.

Mr. Otto Schmitz then read a paper on "Granitoid Curb and Gutter." He explained the conditions of service and gave interesting data regarding some extensive work of this kind just completed in this city. Particulars were given of the composition of the granitoid, the kind of cement used, tests required, etc. A cross section of the pattern used was shown on the blackboard. Results of tests with different kinds of coloring matter and with different proportions of cement and crushed graphite were also given. He called attention to the fact that some further careful experimenting was necessary in order to be sure of the results. Messrs. Bruner, Johnson, Blaisdell, Clark, Hovey and Pitzman took part in the discussion.

The special order of the day was taken up, being the consideration of the report of the committee on affiliation with the American Society, The report is as follows:

Your special committee on the Affiliation of Engineering Societies considers that subject of a closer affiliation has now been sufficiently discussed to justify us in the submitting, for your consideration, the outlines of a plan which seems to us to approach the practicable.

In explanation it seems necessary to say that your committee does not consider it practicable or desirable to establish an organization to embrace all persons who are engaged in pursuits related to engineering, nor such as pursue scientific research other than as means to practical ends. We further think that, of those properly called engineers, a more or less complete segregation, according to special or local interests, is both natural and proper.

The existing national societies of civil, mining, mechanical and electrical engineers have come into existence because their promoters felt a want not fully met by the liberal constitutional provisions of the first-named society, by which all of these several classes are eligible to membership. This shows that persons pursuing like lines of work desire to get together by themselves, at least occasionally. The local organizations find the reason for their existence in the gain, social and professional, which comes from contact between persons whose pursuits have something in common, but which do not run parallel. No proposition which looks to the abandonment of either of these two classes of organization, or which will hinder their growth, is worthy of consideration. The question is: Can they be brought into a closer relationship that will facilitate objects common to all?

Your committee thinks that the term civil engineer is one which embraces all classes of engineers, except those engaged in strictly military work. The American Society of Civil Engineers, which is the oldest of its class in this country, and has retained in its constitution the catholic tradition of its name, is the best nucleus for a general organization. This Society has the further advantage of having in its membership already representatives of all classes of engineers. We, therefore, in outlining a plan of co-operation, assume the American Society of Civil Engineers as the centre.

Probably the American Institute of Mining Engineers, the American Society of Mechanical Engineers, and the American Institute of Electrical Engineers will prefer to maintain a separate position as now. The most that can be looked for is co-operation in the matter of headquarters, offices, building, library and publications.

Of necessity local organizations must be allowed freedom in the management of their own affairs, particularly as to property acquired, dues and conditions of membership.

We propose as an outline of a scheme:

1. To confer upon any body or organization of engineers, one-fifth of whose members are connected with the American Society of Civil Engineers (provided said number shall not be less than ten), the privilege of publishing its papers with those of the American Society, and of becoming, in a certain restricted sense, a branch or chapter of that Society, conditioned only upon the adoption of constitutions and by-laws in harmony with those of the American Society of Civil Engineers, and the observance of certain stipulations.

2. Such bodies to be independent of each other, being represented in the central society, indirectly only, by such of their number as are also members of the American Society of Civil Engineers. They shall be self-governing in all matters pertaining to local membership, dues and expenditures other than a subscription to the publication of the American Society of Civil Engineers, at rates fixed to cover the cost of publication and a reasonable proportion of general expenses, which subscription shall be collected by the local body and paid into the American Society treasury annually in advance, or substantially the same as is now done through the Association of Engineering Societies.

3. Professional papers submitted to the branches, and other suitable matter, shall be published by the American Society, under the same rules and restrictions as are provided for like matter originating in the American Society.

4. As the presentation of papers in either of the affiliated clubs would be a virtual presentation to the American Society, the semi-monthly meetings of the members of the society resident in New York, would be in effect meetings of a local section only, with no greater importance than is given them by the number and character of those in attendance. It would, in fact, be well to provide that the American Society as such should hold but two meetings in each year, one of them to be held in the city of New York and the other at any other place which may be selected. At these meetings all business affecting the general interests of the society should be transacted, whilst all routine business should be conducted by an enlarged board of directors.

To make more definite the steps to be taken to bring about the proposed union of publications, we suggest the following as the form of a constitutional provision to be adopted by the American Society:

ARTICLE........

Any professional society or organization of engineers now or hereafter formed, may become associated with the society for the publication of professional papers upon the following terms and conditions:

A. Such association must consist of not less than twenty-five persons not under twenty-five years of age, who are eligible as members, associates or juniors of this society, and of whom not less than ten shall be, or become members or associates thereof.

B. Such association must have completed its organization, by the adoption of a name, which shall not contain the corporate name of this society: by the adoption of a proper constitution and by-laws; by fixing the conditions of its membership, and by electing the necessary officers.

C. Such association, being thus duly organized, shall then make formal application to this society for admission as an associated club or branch thereof, enclosing with its application a list of its members; a copy of its constitution and by-laws; an agreement to conform to the conditions imposed by the constitution and by-laws of this society upon branches, and other information necessary to identify the body seeking admission.

D. Applications so received shall be submitted to a letter ballot of this society, and if receiving a majority of votes cast shall be granted.

E. When notified by the secretary that the application has been granted, the petitioning body must formally accept, and certify such acceptance by the signature of its presiding officer and secretary, within six months after the date of the notice, otherwise all proceedings shall be deemed to have lapsed.

F. Every organization associated with this society, in accordance with the foregoing provisions, must have continuously in its membership not less than ten members or associates of this society; nor shall the number of such members, associates and juniors, be less than one-fifth of the membership of the branch at any time after one year subsequent to the date of its admission as a branch; it must be responsible to this society for all moneys due for subscriptions for the publications of the society, and must subscribe for at least one copy of the transactions for each of its members who is not also a member of this society in some class. No professional papers shall be published under the name of a branch, except through the society.

G. Any organization having associated itself with the society under the preceding provisions may withdraw from such connections by discharging its obligations in full and giving notice to the secretary of this society of its purpose to withdraw; or for the failure of the associated club to comply with its obligations to this society, its connection herewith may be dissolved by the board of direction by a two-thirds vote, provided that after notice from the board of direction of its default the said club shall for three months fail to remedy its default.

ROBT. MOORE,
ROBERT E. MCMATH, Committee.
JAMES A. SEDDON,

After discussion by Messrs. Ockerson, Holman and Johnson, it was on vote ordered that the recommendation of the committee be adopted as the sentiment of the club. The secretary was directed to inform the American Society and local societies of this action.

It was also ordered that a vote of thanks be extended to the officers of the Merchants' Bridge and Terminal Associations for courtesies extended on the occasion of the opening of the bridge on the 3d inst.

Adjourned. WM. H. BRYAN, Secretary.

328TH MEETING, MAY 12, 1890.—THE TWENTY-FIRST ANNIVERSARY of the Incorporation of the Club, was celebrated by an informal supper at the Elks' Club. The members sat down at 8:45 p. m., President Nipher in the chair, and the following members present: Abend, Arnold, Baier, Baker, Barns, L. Bartlett, Bascome, Beahan, Belcher, Bouton, W. H. Bryan, George Burnet, Chape, Clark, Crosby, Crow, Farnham, Goltstein, Gould, Groneman, Hovey, Hubbard, J. B. Johnson, Jones, Judson, Long, Love, R. E. McMath, R. H. McMath, Macklind, Meier, Melcher, Milner, R. Moore, Nipher, Oekerson, R. Parker, Pegram, Pond, Russell, Schaumleffel, Sherman, Tideman, Vail, Wheeler, Winslow, Wise, Woodward.

After doing justice to the supper, the meeting was called to order by President Nipher, and the following toasts were responded to: "Our Guests," Robert Moore; "The Day we Celebrate," C. M. Woodward; "Our Past Presidents," R. E. McMath; "Bohemia," J. B. Johnson: "The Engineer at Large," Willard Beahan; "Bed Rock," E. D. Meier.

Professor Johnson, in his remarks, called the Club's attention to the valuable services rendered the Club in past years by the late Prof Chas. A. Smith, for many years Secretary of the Club. He stated that it would be a fitting recognition of those services to raise a purse for the Professor's son, who was just entering upon a course of advanced study, and he believed that such a testimonial from the Club would be appreciated. The subscription paper was passed around, and liberally signed. After a most pleasant evening, the Club adjourned at 11:45 p. m.

WM. H. BRYAN, Secretary.

329TH MEETING, MAY 21, 1890.—The club was called to order at 8:20 P. M., by Prof. Nipher in the rooms of the Elks' Club, there being nineteen members and three visitors present. The minutes of the 327th meeting were read and approved.

An application for membership was announced from Jas. G. Jennings, assistant engineer street department, city of St. Louis, endorsed by George Burnet and Willard Beahan. This was referred to the executive committee.

Prof. Johnson announced that the purse to be presented to the son of the late Prof. Smith—for many years secretary of this club—had reached nearly $270.

The paper of the evening, by George A. Brown, entitled "The Function of the Government in a Plan for General Irrigation," was then read by Prof. Johnson. The paper discussed at some length the necessity of providing some more complete and systematic method of dealing with the problem of the artificial distribution of water for purposes of irrigation, this problem being one of great importance, especially in the Western States and Territories. The author claimed that the arid region was nearly as great in extent as the remaining portion of the country, and the land was of but little value without water rights. The government is now asked to determine the amount of water available for the purpose and to provide laws regarding its distribution and apportionment. He thought the government should give a title to certain water privileges, the same as it gives to land. The author was connected for a short time last season with the irrigation survey work done by the government in Western Nevada, under the direction of Maj. J. W. Powell. Incidentally, the writer discussed rain fall in general, and as affected by forests.

Mr. Nipher called attention to the effect which general irrigation might have on the distribution of rain. It is claimed that the rainfall of Kansas is increasing. He regarded this question as an open one as yet. The early rain records are not very reliable and comparisons of early rainfall records with those now made are to be made with great caution. Public opinion in such matters is of even less value, especially when there are real estate interests involved.

Formerly it was thought that rainfall was greater in forest regions than in open plains. Observations in some European regions, notably in Bohemia, were relied upon to show this. This idea is certainly a wrong one. In order to examine this and other collateral matters he had in 1880 designed a rain-gauge having around it a flaring trumpet-shaped shield, with the mouth upwards. Suitable precautions against the splashing of rain from the shield into the guage were arranged, and it was found that a gauge protected from the wind in this manner, gave a greater rainfall than when not protected. The rainfall with the shielded gauge gave the same

results as a gauge exposed in a pit, with its mouth at the surface of the ground. His gauge had been tested by Wild in St. Petersburg and by Boernstein in Berlin, and their reports, after several years of test, gave the same result as was reached by Mr. Nipher.

The reason formerly given for the greater rainfall in gauges near the ground than those at higher altitudes, was that it was due to condensation of moisture around the falling drops. This as well as the observed excess of rain in forests is simply due to the effect of wind. The wind sweeps over the mouth of the gauge with a greater velocity than it would have at that point if the obstacle were not there, and the rain drifts to the leeward of the gauge. The best exposure for a gauge is an open space in a forest. A fence of pickets was placed around a gauge at St. Petersburg and it was also found to serve the purpose.

Mr. Nipher stated that timber land in Iowa was now selling for about half what it was worth twenty-five years ago. This is due in part to the barbed wire fence but vast regions which were then treeless prairies are covered with groves and the stunted shrubs which were then annually visited by fire have grown into forests which now have as great an effect upon the rainfall as they ever will have. There is, however, not the slightest evidence that the rainfall of Iowa is increasing.

Mr. Robert Moore stated that such investigations as he had been able to make had satisfied him that the popular opinion that forests increased the amount of rain fall was a fallacy, and he was glad to see the matter set at rest authoritatively. Messrs. Johnson, Blaisdell and Curtis also took part in the discussion.

Adjourned WM. H. BRYAN,
Secretary.

330TH MEETING, JUNE 4, 1890.—The Club met at 8:15 p. m. in the Elks' Club rooms, President Nipher in the chair; thirty members and three visitors present. The minutes of the 329th meeting were read and approved. The Executive Committee reported the doings of the 92d and 93d meetings, announcing that the journals of all delinquents had been ordered stopped, and that the names of W. Adams, J. W. Cordes and R. D. O. Johnson had been dropped from the rolls. The Executive Committee reported the approval of J. G. Jennings' application for membership. He was balloted for and elected.

Col. Meier, president of the committee on Eads' monument, announced the formation of the Eads' Monument Association, and suggested the advisability of members of the Club joining the Association. He stated that a meeting would be held at the Mercantile Club at 3 p. m. on Saturday, 7th inst., to effect a permanent organization.

Mr. Russell, chairman of the committee on local data, then presented his report. The nature of the matter collected was explained, and the ground covered, and the names of the contributors were given. Some informal discussion of the matter presented took place, participated in by Messrs. Potter, Meier, Russell, Bryan, Seddon, Nipher, Crosby and Farnham.

On motion of Prof. Potter it was ordered that the committee be continued with authority to employ expert assistants, if necessary, to edit the report, and to secure for the Club estimates on the cost of publication, the treasurer to be made a member of this committee when matters of expense were under consideration.

Prof. Nipher called attention to the fact that rainfall in the State of Missouri was almost exactly equivalent to the river discharge at St. Louis.

It was on motion ordered that an extra meeting be held on June 18.

Adjourned. WM. H. BRYAN, Secretary.

BOSTON SOCIETY OF CIVIL ENGINEERS.

REPORT OF THE COMMITTEE ON WEIGHTS AND MEASURES.

To the Boston Society of Civil Engineers:

Your Committee on Weights and Measures respectfully presents its annual report as follows:

The question of weights and measures in this country remains substantially the same as it was a year ago.

The Metric system is increasingly used in technical literature, and its terms are frequently seen in the newspapers.

A little book entitled, "The Essentials of the Metric System," was recently published in this city and will tend to make the methods of that system more familiar. It is a brief treatise on decimal arithmetic.

The United States Coast and Geodetic Survey has recently published some valuable conversion tables, including linear, square and cubic measures and containing such units as the chain, square mile, fathom, nautical mile, British gallon, bushel, etc. They are accompanied with foot notes which give additional information concerning standards of measurement and the legal status of metric measurements in the United States.

The International American Conference has adopted the following recommendation of its Committee on Weights and Measures:

"The advantages which the metrico-decimal system offers are so evident, and as it has been already adopted by so considerable a number of nations, your committee recommend:

That the International American Conference recommends the adoption of the metrical decimal system to the nations here represented, which have not already accepted it."

The most important occurrence during the year concerning the metric system has been the reception and acceptance by the President of the United States of the national prototypes, the meter and kilogram allotted to this country. These prototypes were made at Paris by the International Bureau of Weights and Measures. Your Committee on the Metric System described the work of this bureau at considerable length in its report of March 21, 1883. Dr. B. A. Gould, in a valuable paper read before the Society at its annual dinner last week, gave a description of the prototypes and some of the results attained during the process of testing them. Your Committee hopes that this interesting and valuable paper may be printed by the Society in the same number of the JOURNAL that will contain this report.*

Your Committee is informed that during the past year the use of the metric system has become obligatory in Sweden.

The notation of time according to the twenty-four hour system continues to be agitated among railroad officials and others and there is reason to believe that it will soon be generally adopted in railroad time-tables. The recent report of the Committee of the American Society of Civil Engineers gives interesting statistics concerning its progress.

For the Committee,

CHARLES H. SWAN,
Chairman.

BOSTON, March 19, 1890.

MAY 21, 18 0.—A regular meeting was held at the American House, Boston, at 20 o'clock. President Herschel in the chair. Forty-six members and fifteen visitors present.

The record of the last meeting was read and approved.

Messrs. Geo. F. Chace, Thomas M. Drown and William T. Sedgwick were elected members of the Society.

The President announced the membership of the Committee on Excursions which had been selected by the Board of Government, as follows: G. A. Kimball, Fred. Brooks, J. A. Gould, Jr., Charles Mills and F. O. Whitney.

The consideration of the following report, presented at the last meeting and assigned to this, was then taken up.

REPORT OF THE COMMITTEE TO CONFER WITH THE AMERICAN SOCIETY OF CIVIL ENGINEERS' COMMITTEE.

To the Boston Society of Civil Engineers:

From Mr. Wm. P. Shinn, the chairman of the American Society of Civil Engi-

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*Dr. Gould's paper is printed on page 283 of this number.

neers' Committee on Revision of Constitution and By-laws, a circular letter, dated March 26, has been received, which requests the Boston Society's Committee of Conference to present in writing any suggestions for the establishment of close relations between the societies, and states that the American Society of Civil Engineers'Committee is to meet June 4, at New York, where it will be pleased to receive the Boston Society of Civil Engineers Committee. Accompanying the letter are various typical propositions which have been received by the American Society of Civil Engineers' Committee, and are designated as "A," "B," "C," "D," and "E." "E" is a carefully drawn statement of the difficulties in the way of a union of societies; the other four are plans for the establishment, by the American Society of Civil Engineers, of local branches which are forbidden to act in the name of the American Society of Civil Engineers. "A," "B," and "C" require branch organizations to be consistent with the American Society of Civil Engineers' Constitution; and "A" and "B" expressly forbid branches to act officially on public questions without the previous approval of the American Society of Civil Engineers. "A" and "B" allow branches to elect to membership of a subordinate grade in the American Society of Civil Engineers, but "B" makes approval by the American Society of Civil Engineers a requisite; "C" limits membership to the various grades of members of the American Society of Civil Engineers. By "A," all property is to be held in the name of the American Society of Civil Engineers, but may be in trust for a branch; and it is suggested that any existing local society wishing to become a branch be first dissolved; by "B" and "C," property may be held in the name of a branch; and by "B" an existing local society may become a branch in the same manner as a new organization. Copies of plan "D" have been made for distribution, by the courtesy of Prof. Porter. A draft of a letter which we have prepared to send (if sufficiently encouraged by the action of the Boston Society of Civil Engineers), as a reply to Mr. Shinn, chairman of American Society of Civil Engineers' Committee, is attached hereto, and forms a part of this report.

Respectfully submitted,

FRED. BROOKS.
DWIGHT PORTER,
SIDNEY SMITH,
Committee Boston Soc. C. E.

BOSTON, April 16, 18 0.

DRAFT OF PROPOSED LETTER.

BOSTON SOCIETY OF CIVIL ENGINEERS,
BOSTON, April 1890.

WM. P. SHINN, Esq.,
Chairman Committee on Revision of Constitution and By-Laws,
American Society of Civil Engineers,
127 East Twenty-third St., New York, N. Y.;

Dear Sir,—In reply to your esteemed favor of March 26, we, a committee of the Boston Society of Civil Engineers, have to confirm what we wrote you 11th October last. We may add, in reference to the plans which you are so good as to send us, that plan "D" is the one that seems to us best adapted to meet the views of the Boston Society of Civil Engineers. The leading objects which we hope to attain by the establishment of relations between societies are, to afford opportunities for the members of different societies to discuss each others' papers and projects, attend each others' meetings and excursions, and have access to each others' rooms and libraries, with equitable adjustment, of course, of expenses. Plan "D" explicitly states its purpose to be to promote the presentation and discussion of papers, and by consequence, social and professional intercourse. If the American Society of Civil Engineers and the local societies with which the Boston Society of Civil Engineers is now associated in the Association of Engineering Societies shall unite in favoring plan "D," with perhaps some little modification of its details, we have no doubt that the Boston Society of Civil Engineers will gladly cast in its lot with the

rest. That is to say, we think the American Society of Civil Engineers might decide that the Boston Society of Civil Engineers, with its own name, charter, constitution, by-laws, library, money in treasury, etc., was acceptable as a branch, and was to be included in the system of exchanges provided for in plan "D," so long as the two societies should see fit mutually to continue the relation.

We notice that plans "A," "B," and "C" provide somewhat similarly to plan "D" for the transmission of papers and discussions, but go further, and add various provisions for organic connection to be made by changes of constitution of the societies. After the exchange of papers contemplated by plan "D" shall have led to better acquaintance, and have augmented the feeling of relationship between the members of the American Society of Civil Engineers and the Boston Society of Civil Engineers, perhaps some organic union will naturally be effected. Whether such organic relations should now be entered into between the American Society of Civil Engineers and other societies, while the Boston Society of Civil Engineers remains connected only by plan "D," or some equivalent, we do not feel called upon to discuss.

We hope that before June you may be so kind as to inform us of the general tenor of your committee's own views, and, perhaps, also tell us something of the opinions controlling our sister local societies.

Cordially yours,

PLAN D.

I. Branches of the American Society of Civil Engineers may be authorized by the Board of Direction at points where in its judgment the membership is sufficiently large to warrant a local organization.

II. The sole object of authorizing the establishment of such branches, so far as the American Society of Civil Engineers is concerned or involved, is to encourage and to facilitate the presentation and discussion of papers, with the consequent promotion of social and professional intercourse among neighboring members and others enjoying a community of interests with them.

III. Branches may make their own rules and regulations regarding organization, membership, and proceedings, but the name of the society shall be used only as authorized by its Constitution and By-laws. Membership in a branch does not of itself constitute membership of any class of the American Society of Civil Engineers.

IV. Advance copies of papers presented to the society shall be sent to each branch for discussion, and each branch shall send an advance copy of every paper presented to or read before it to the Secretary of the Society for presentation to the society, and for distribution to other branches. Copies of all discussions shall also be forwarded to the Secretary. Such papers and discussions shall be considered as though had before the society.

V. Branches shall be supplied with any number of copies of papers and their discussion, upon the same conditions they are now furnished to members of the society. Should any branch desire to be supplied with complete copies of the Transactions, the Board of Direction is authorized to fix an equitable rate of subscription for the same

VI. An existing local engineering society may become a branch of the American Society of Civil Engineers, provided it come within the conditions of Section 1 of this Article.

VII. The Board of Direction is authorized to formulate from time to time the necessary rules for carrying into effect the provisions of this Article.

VIII. The Board of Direction may at any time by a two-thirds vote of all its members dissolve any branch, so far as its relations with the society are concerned. No such vote, however, shall be valid, unless it include a majority vote of all the non-resident members of the Board.

After a general discussion of the report and proposed letter, it was voted: That the Committee be requested to write Mr. Shinn in substance as proposed in the draft submitted, omitting the last sentence.

Prof. C. F. Allen then read, at the request of its author, a paper entitled "Improved Railroad Terminal Facilities in Providence" by S. L. Minot. The paper was discussed by Mr. E. P. Dawley, Chief Engineer, N. Y., P. & B. R. R., who was associated with with Mr. Minot in designing the improvements.

Mr. L. B. Bidwell read a paper describing the Asylum Street Improvements at Hartford, Conn.

The papers were discussed by Messrs. Allen, Kimball, Locke, Oliver, Parker and Sampson.

Adjourned. S. E. TINKHAM, Secretary.

WESTERN SOCIETY OF ENGINEERS.

MAY 7, 1890.—The 269th regular meeting of the Society was held at its rooms Wednesday evening, May 7 1890, at 8 o'clock P. M., President L. E. Cooley in the chair, and some seventy-five members and visitors present.

The minutes of preceding meeting were disposed of and the report of Directors' meeting was read by the Secretary. Nothing of importance outside of the election of members and the consideration of applications for membership was on record.

The following new members were elected: Messrs. Dwight H. Perkins, Geo. F. Wightman, Edward W. Dewey, John M. Ewen, Ralph M. Shankland, Walker Miller, Frank G. Ewald, Charles Hansel.

The following applications for membership were recorded: Messrs. Frank F. Heck, John Henry Spengler, Samuel V. Ryland, James J. Reynolds, Henry Furlong Baldwin, Emil Gerber, Fred T. Rolph, Chas. J Peters, Edward Shelah, H. S. Houck.

The communication from the American Society of Civil Engineers, asking for an expression of views relative to an affiliation with local Societies, was submitted to the Society.

Mr. C. L. Strobel suggested the appointment of a committee to report an expression of views to be sent to the committee of the American Society. He moved that a committee of five be appointed. It was understood that this would not commit the Society without further action on its part.

The motion was seconded and carried. The President later appointed the following: Messrs. Benezette Williams, H. B. Herr, O. Chanute, A. F. Nagle, Geo. S. Morison.

The President then introduced the subject of the evening's discussion: "The Chicago Railway Problem." The committee appointed at the previous meeting had submitted majority and minority reports which were read by the Secretary.

The Secretary read communications from Mr. A. Onderdonk, Mr. E. T. Jeffery, Mr. J. D. Springer, Mr. Stuyvesant Fish, Mr. H. H. Porter and Mr. E. St. John.

Mr. Ossian Guthrie then presented a paper describing the growth of Chicago from its early days. See page 273.

The President then called upon Mr. C. J. Roney, who had spent much time in compiling statistics of the amount of work done, and money expended by the city and railroad companies on the viaduct system. Mr. Roney will present the matter, in available shape at a later date.

Mr. A. F. Robinson then presented a paper on the Cost of Four Track Steel Viaducts with Brick Piers, and Four Track Brick Viaducts. (This paper will be found on page 276.)

The President then called upon Mr. R. P. Morgan. Mr. Morgan read a paper in which he gave his views on the conditions governing the question, and made comparisons with New York City. See page 280.

MR. GEO. S. MORISON said: I do not know that I have anything to say except what is outlined in the minority report. That report was intended to outline the features of a scheme which it was thought would prove a solu-

tion — recognizing the fact that that outline was subject to a great many criticisms, and before any such scheme was adopted, a great many details would have to be worked out, and a great many changes made. The fundamental principle, it seemed te me, — and Mr. Strobel concurred with me, — was that we must get rid of all dangerous crossings, both streets and railroads, streets with railroads, and railroads with railroads; that that must be done in whatever method would disturb existing interests the least: and, as Mr. Morgan has just stated, here in this central and valuable district of the city — one half belongs to railroad and transportation interests, and is used by railroads and transportation interests. The first feature must be not to disturb those interests in that locality to any greater extent than is absolutely necessary. The lines must be arranged so that street crossings will be avoided, but at the same time existing interests protected. The basis which seemed likely to do that was to make the railroads that pass in one direction, pass under the railroads that pass in the other direction, and apparently it was easier to put the railroads that ran east and west under those running north and south than the opposite, especially as several of the streets which cross the east and west railroads have been viaducted, at very large expense That was the general outline which occurred to us, and as I have stated, it is an outline, and not a perfected scheme. There are a great many details to be worked out, and we did not attempt to go into detail of construction at all. Mr. Robinson has two plans—one entirely masonry construction, the other partially masonry and partially iron. It is a gratifying thing to see that the brick construction proved cheaper. On the other hand there are some very serious objections to using arch construction with the class of foundations used in Chicago, and I cannot help thinking that a construction almost entirely metallic would be the form of construction which would be, in many places, desirable. But it seems to me that the details of construction do not come up as a preliminary. The first thing to determine is whether some general plan can be formed, can be arrived at, which, without disturbing existing interests too much, will avoid existing dangers. Then let the details follow.

Mr. John F. Wallace.—In a line with what Mr. Morgan has said, and as Mr. Morison has mentioned, it seems to me that the only practical line of investigation would be this. Owing to the amount of capital now invested in the present arrangements inside of the business limits, it seems that it will be almost impossible to radically disturb anything north of Twenty-second street, south of Kinzie street and east of Western avenue. After the Lake Shore tracks cross the line at Sixteenth street, however, it would be practicable to elevate those tracks to the limits of the city, and after the Santa Fe and Alton leave the Western Indiana tracks at Twentieth street, it would be possible to elevate those tracks, but it seems almos impossible to undertake any change in existing tracks inside of those limits without an enormous outlay of money, and without such a radical change that it would cause a complete change in the way the industries are at present carried on in the heart of the city. It might be possible, in a few years, to have an elevated system that would provide for rapid transit outside of the heavy business district at an expense that would be inside of the limits of the various railways. Of course that would be based on the idea that the City would meet the railroads, and the expense would not fall entirely on the railroads. In regard to the eliminating of crossings inside of the business district, that is practically an impossibility, and right here you will see a blue print that shows the different ownership of the different tracks, at the intersection of Sixteenth street and Clark, there are four or five different systems of road that cross each other at that point, and it is one of the places where it would be impossible to attempt to disentangle the lines. At such places as that the only solution of the question is the design and operation of improved interlocking systems, and to give the Society an idea of what a system of that kind would cost, I would say that the interlocking plant would cost from $65,000 to $70,000 The boundaries of that district are now so narrow, that if the tracks were elevated, the grade railroad crossings and also the street crossings were eliminated outside of it, it would go a long way towards the solution af the question.

Mr. Nourse.—I do not believe I could give anything valuable, but I have always, up to recent years, had an idea that by placing the passenger tracks as a second story to the present surface tracks, leaving them as they are, and keeping

the elevated tracks strictly for passenger service, and such movements of the cars as had to be done in the daytime—moving the freight cars on the present circuits only at night. Then such tracks as must necessarily cross each other, could be protected by the interlocking systems. Also by using the belt systems, and interchange of cars wholly outside of the City, or in the sparsely settled portions of the City.

MR. W. R. NORTHWAY.—There is this one point I have thought of that Mr. Robinson brought up in his estimate here to-night. Speaking of the rental of space under tracks,—a great many of these tracks do not face any street whatever. They go through the middle of the block. It would require, in order to make those spaces valuable, that an alley should be opened, or else a portion of that space should be made an alley, to make the space valuable, so that the percentage you speak of would be, to a certain extent, decreased. This matter of using space under the tracks I thought of myself. The point had come up to me before.

MR. ROBINSON. The matter of not having any connection with the room between streets was considered. It was expected to connect the series of rooms by archways through the piers. A narrow gauge track could be laid through these rooms, and connection could be made in that way from street to street. There would of course be room enough left on the one side or the other to allow light to come through, so there would be no trouble from that cause. I would say that in Berlin they have built four track elevated road. It is a sort of a belt line, and through the thickly settled portions of the city the room or space under the arches is used for stores, and it brings in quite a good per cent. on the cost of the system. I can not say how much; but it is quite an item in the returns of the investment, and they find no difficulty in renting these same rooms. There is no trouble from noise; no special trouble, and of course they have to leave on one side or the other an alley way for entrance and exit, or else connect the rooms in the manner I spoke of.

PRESIDENT.—There is one thought in connection with this matter which was brought up by Mr. Morgan, which I think we are all too prone to lose sight of, and that is the relation which our river bears to the commerce of this City in distributing heavy products—coal, lumber, and things of that kind. My thought has been specially directed to it in the past few days, in connection with the Drainage and Water-way question, or the Water-way relations of the Drainage question, which we have with the State, and to a certain extent, the United States, necessarily impressed upon us by State law, and I was astonished beyond measure to find the extent of property in this City which you might call marine property, which is directly dependent upon the river for its life and use. I find that our harbor, what we are pleased to call our river, in the heart of the City aggregates over 400 acres of actual water surface, and the extent and lineal length of river and slips which are dredged and actually docked, is something over 20½ miles. The actual dock frontage, which is used for purposes of transportation and commerce, is something like 37 miles all told, and the actual number of acres of property, which is marine property, about 1,240 acres; so we have here, in the heart of the City, nearly three square miles of property which is either river or dependent upon the river, and valued at not less than $100,000,000. In some statistics which Mr. Corthell made for the World's Fair Direction he stated that the number of tons which came to Chicago and were forwarded, was 43,000,000 per annum. In a computation which I have made up, the marine commerce here, in addition to that, including the Illinois and Michigan Canal, was something like 11,-500,000 tons per annum, something over one-fourth of the railway movement at this point, or about 20 per cent. of the total. I find, on making comparisons with other cities, that our marine tonnage is very nearly equal to the entire movement at St. Louis—railway and everything else combined, and that the total movement at Chicago is about four times the total movement at St. Louis. There are a good many other things of this kind which are very interesting. Our people have been in the habit of considering relief which we would get in the heart of the City, from one main annoyance—by closing the bridges, etc., which in a sense is as serious as the railroad question. They have looked to the Calumet Region, and to an outer harbor to bring us relief, but commerce exists where people exist, and where people exist commerce is always conducted under certain difficulties, and the result of it is that we cannot get rid of our marine nuisance, or very likely of our railway nuisance, unless we move to some other locality and wait for the commerce to come to

us again. It has been represented to us that there are great facilities for commerce within ten or fifteen miles of this City. There are certainly great facilities, but very little commerce. It does not seem to have occurred to the people who have advocated moving the commerce to that point, that if the commerce were moved, the people would move, and the nuisance would also go there.

I have no special thought to express in the matter, further than to say that in regard to projects for the improvement of our marine facilities, such as the Lake Front scheme, that we have this to contemplate. A vessel like the Susquehanna goes up the Chicago river and stops the traffic of this city for three minutes. It is a question whether that is a more serious matter than it is to have 1,500 teams hauling her cargo and distributing it around this city; and it is a question about the railway as to whether it is a more serious matter to have the railway running through and about our population, carrying in large lots, to the actual centres of industry, or to have teams going about doing the same thing on a far greater number. The question is so broad that it is a pretty difficult one to handle. I was in hopes that the city had made a very large appropriation by which several members of the Western Society of Engineers could be employed for a considerable time in solving this question on a broad scale, but I learn that no move has been made in this direction. How we are going to get at it I do not know. What to do further in the matter in this Society I do not know, and that is the reason I took the floor, to virtually ask that question, and not to preface it by a long series of remarks, which are not exactly relevant to it. What shall we do with this question in this Society? All of the points are pretty well suggested. It is largely a matter of detailed consideration in each case, and as a whole, by men who will give their time to it from now on, to solve this question, and bring out its multiform relations. Individuals of this Society can not be expected to do it, and we have covered the general question. What farther can we do by discussing it? We can appoint committees, we can urge action, and that is what we want light upon this evening. What shall we do with this subject? We have it here and want to take care of it and dispose of it. If we are going to discuss the thing further in detail, with a view to getting at some recommendation, or some suggestion as to the result of our discussion, then it is evident that we can not finish this to-night. What is the further suggestion in the matter? Has the committee anything further to offer as to what we shall do with this question?

MR. MORGAN.—It seems to be the opinion of all that the subject is one of great importance, and that there are other subjects of great importance also pending pertaining to the growth of Chicago, and as a member of this Society I should take great pride in having the Society formulate those great things instead of allowing them to drift along, and, perhaps, become the victims of the public, instead of being acted upon intelligently through a society having the purpose that this one has. I feel that I ought not to say too much to-night, but I certainly would be disappointed if the Society in any way seemed to allow these great questions to drift along. The purpose of the Society is to guide and give intelligence on all these things. Of course, on details of construction, engineers would then be employed, and I trust they would be liberally compensated, but this is a labor of love, and love of the profession, and it seems to me that we ought to stick to it in some form, and do something that would be a credit to the Society.

PRESIDENT.—It is certain that this question, and the other questions which are related to it, the two or three questions which have been suggested this evening, are all cousins. You can hardly treat one of them without treating the family. They are subjects which can well occupy the Society for several meetings. No question about that, and I would like to see the Society continue in their discussion. There is a great deal of matter presented this evening which ought to be put into print, so that every member of the Society can have access to it, and can get a new point of departure for further thought and further discussion, and as nothing has been determined as to the course which we should adopt after this evening, I was in hopes the Society would express itself in regard to what we should do further in the premises. If the matter is to be printed and continued, all well and good.

MR. WALLACE.—The railroads and the city will not call on us for assistance unless they know that we are willing to assist them, and while it may not do the railroads any good, it will do ourselves good to stir these matters up, and ventilate them,

and I know of no body of men who are better capable of attracting public opinion to a matter of this kind than the Western Society of Engineers. If we are going to be a power in the comunity I think it is time we should take such steps as to attract attention to ourselves and to the profession. This question is very pertinent, and one which we should consider and bring before the public, and I think we have made a very good commencement at it, and do not think we ought to let go of it. In fact, I do not think we can let go of it very gracefully. I move that the question be continued for discussion next meeting, and that the matter that has been presented to the Society be printed and distributed among the members. Motion seconded and carried.

Mr. Stuyvesant Fish, Prof. H. B. Herr, Mr. W. R. Northway and Mr. Chas. Macdonald, then made brief replies to questions put to them.

Prof. H. B. Herr coincided in the view that the discussion should be continued.

After some discussion the Reports of the Committee were accepted and the Committee discharged.

Mr. Max E. Schmidt offered a resolution in reference to calling upon the members of the Western Society of Engineers, to subscribe toward assisting the Engineer's Club of St. Louis in errecting a monument to the late Capt. Jas. B. Eads. Accompanying the resolution a letter of eulogy was read from Col. Meier, of St. Louis.

The following is the resolution :

WHEREAS, The Engineer's Club of St. Louis has inaugurated a movement to erect a monument to the late James B. Eads, whose eminence as a civil engineer has made him worthy to be thus honored,

Resolved, That this Society indorses this movement of the Engineer's Club of St. Louis and desires to co-operate therein.

Resolved, That a copy of this resolution be sent to every member and junior of this Society, and that the Secretary be authorized to receive contributions toward the monument fund.

The President regretted the absence of Mr. Corthell who was so intimately associated with Capt. Eads.

The motion was unanimously carried.

Adjourned.

JOHN W. WESTON, Secretary.

Editors reprinting articles from this journal are requested to credit both the JOURNAL *and the Society before which such articles were read.*

ASSOCIATION OF ENGINEERING SOCIETIES.

ORGANIZED 1881.

Vol. IX. July, 1890. No. 7.

THE PARIS EXPOSITION OF 1889.

BY O. CHANUTE, MEMBER WESTERN SOCIETY OF ENGINEERS

[Read February 5, 1890.]

The great and successful exhibition which lately closed in Paris, was largely the work of Engineers. In its design, its construction and its management, they bore a conspicuous and leading part, and it will therefore be interesting to you to attempt a brief sketch as to what was done, in an engineering way, to make it so attractive, together with some hints as to the applicability of these methods to a similar undertaking in this country.

With this in view I shall divide my remarks under three heads, 1st, the general management; 2d, the character of the buildings, and 3d, the arrangement of the exhibits.

THE GENERAL ARRANGEMENT.

On the 3d, of May 1886; a year and a half after the Exposition had been decreed, and three years before the date set for the opening, the French Minister of Commerce issued a circular inviting French Engineers and Architects to submit competitive plans for the general arrangement of the Exposition buildings and grounds, upon certain lands which were designated; and under certain conditions which were laid down.

Only 18 days were allowed for the preparation of these designs, but in point of fact quite a number of Engineers and Architects had been thinking of, and discussing the subject for years, and at the time set, no less than 107 designs were presented.

Of these, 18 were selected by a special committee as the most meritorious, and to them were awarded prizes, which we should consider quite

inadequate in this country. The first twelve received prizes varying from $800 to $200, and the remaining six received honorable mention. It should, in fairness, be stated however, that the hope for money prizes was not the sole incentive in this competition. Not only was there the distinction to be gained by the selection of a design as among the best, and the probable future engagement to carry it out, as in fact occurred in most cases, bnt there was also the hope of a decoration in the "Legion of Honor" which is so eagerly sought for, and so highly prized in France. The best Engineering and Architectural talent of the country, as well as the best efforts of the designers, were enlisted in the enterprise from the start, and all those who have seen the results agree that they were exceedingly good. The Exposition was the most brilliant and beautiful which has ever been held, and all things considered it was carried out at a wonderfully small cost.

I am decidedly of the opinion that a like course could profitably be followed in this country for the proposed exposition of 1892, for in no other way can so many valuable suggestions be elicited, and so much talent enlisted in making a success of the engineering of the enterprise.

The 18 designs which received prizes, became the property of the State. From them the final plans were prepared by the Engineers selected by the Administration, aided by some of the competing Architects.

These final plans were eclectic; that is they were based upon the selection of various features which were thought to be most meritorious in the various designs presented. It is worthy of note that the result was, it is conceded, an improvement upon any one of the original designs. I have obtained, and now place on file in the library of this Society, the first eleven designs which received prizes, and I believe that an examination will convince such of you who may wish to compare them, that no one of them would have been quite as effective and attractive as the plans finally adopted.

The one feature in these plans which has been thought most deserving of praise, is the wide central garden on the Champ de Mars; it was about 1,400′ long and 700′ wide, and thus admitted of making the principal architectural display on the inside, instead of the outside of the Exposition, as well as of concentrating therein the most brilliant and attractive of the illuminations and displays. I will presently attempt to describe this portion of the Exhibition to you.

All experts agree that the Paris Exposition of 1889, was far more gay and brilliant than any which had preceded it. The Exposition of 1867, and especially that of 1878, had been criticized, as being wearisome to visitors, and less bright and amusing than they ought to be, and this mistake was certainly not committed in 1889.

In 1867 the main buildings were arranged on the plan of an immense ellipse. This was divided into a series of concentric halls, connected by radial passages. Each hall contained one group of exhibits, space being assigned radially to the nations adjoining each other. This arrangement was based upon the theory that visitors might thus compare, either the similar products of all countries by following one of these elliptical halls, or see all the products of one single country by following its radial pas-

sages. This ingenious idea met with universal approval when first it was suggested, but it was not found to work well in practice, because the nations did not furnish like proportions to the various groups.

The same idea was taken up again in 1878, but was then carried out somewhat differently. The buildings were made rectangular in plan and the exhibits arranged on the principle which the French Engineers designate as that of the "Table of Pythagoras."

But there again the result was not satisfactory. Some nations chiefly sent raw materials, and these, to be sure, fairly represented their industry, but they unduly crowded the space allowed for such products, while the same nations sent little or no manufactured goods, and the space assigned to these proved much too large. Thus the exhibits and the countries interfered with each other, and serious difficulties occured which marred the general effect.

In 1889, it was decided to sacrifice theory to practice, to make above all a display pleasing to the eye, even if visitors with scientific inclinations were hampered in making comparisons. The result of this decision as viewed from the outside and inside of the buildings, was positively marvelous, it was a fairy scene in the open air, and it will be very difficult to surpass, or even to equal it.

It is impracticable to convey in words the impressions which were left on the eys of the visitors, yet with the aid of a few cheap colored prints which I brought back from Paris, and have presented to the Society, I will endeavor to give you a rough idea of the general arrangement.

The first of these prints is a general bird's eye view taken from the hill near the Trocadero, and showing chiefly the buildings on the Champs de Mars, and those along the Quai d'Orsay; the portion on the Esplanade of the Invalides being two far in the background to give even an idea of its architectural appearance.

The next, which is also a bird's eye view, supposed to be taken from the side of the Champs de Mars, gives a fairly correct idea of the general arrangement of the buildings, on this, the principal ground of the Exposition, which is approximately 1,500′ wide and3,700′ long.

The third is a view of the Eiffel tower, as seen by day, from the banks of the Seine on the Trocadero grounds.

The central garden stretches out lengthways behind the tower and is is terminated by the Grand Dome of the central Transept, while beyond rises the roof of Machinery Hall. On the right, the Liberal Arts building, and on the left the Fine Arts buildings are indicated by their domes, while the various edifices shown between them and the Tower, are a foreshortening of the Pavilions of the several nations.

The fourth is an outside view of the Central Dome, which faces the Eiffel tower, at the other end of the Central Garden.

This dome was generally acknowledged to be the most beautiful Architectural object about the Exposition. It is 98′ in diameter, and rises to a height of 200′; the framing being wholly constructed of wrought iron. It is, as will be perceived, elaborately and artistically ornamented, this feature also extending to the interior, which is almost as beautiful as the exterior here shown. (Lithograph shown).

The fifth is an interior view of the dome surmounting the Fine Arts Palace. This is 100′ in diameter and 197′ high, and yet it produces far less effect, both on the outside and on the inside, than the dome over the Central Transept previously described. Most casual observers would get the impression that the Central Dome was the largest, as well as the most beautiful of the three; for both the Fine Arts and Liberal Arts buildings are similar in construction.

Beautiful as these buildings were by day, the scene became still more fairy like at night, when a flood of electric light was poured over the grounds, and the outlines of the buildings were brought out by rows of gas jets, or by the powerful beams from the top of the Eiffel tower.

On festal occasions, still other and more dazzling effects were produced with colored fires, and the sixth print represents fairly what was called "the conflagration of the Eiffel Tower." While this, together with the next picture indicates what masters the French are, in the art of illumination.

The seventh shows approximately the effect of the luminous fountains, which were located in the central garden, between the Eiffel tower and the Central Dome. By means of mirrors or reflectors placed in crypts beneath the fountains, powerful beams of electric lights were projected centrally into the water jets, passing on their way through colored glasses, which were constantly changed at the will of the hidden operator, so that the 48 water effects rising into the air were constantly changing in hue.

The eighth and last picture gives a glimpse of one of the many outside attractions, in the reproduction of an old street from Cairo. It was said to be very accurate, the houses having been exactly copied, and the wood-work and balconies having been procured in Egypt during the tearing down some old houses. The shops were occupied by native workmen, plying their trades, or selling curiosities from their country, and in two so called concerts, bands of Egyptian and Morocco performers gave specimens of the voluptuous dancing of their country. This was the most popular of the outside attractions within the Exposition grounds, but there were many others. Among them may be mentioned three theatres, of the variety order, two panoramas, a terrestrial globe 40′ in diameter, six or eight other exhibitions of dancers, the most admired of which was that of the Javanese girls, and fifteen or twenty concerts charging popular prices and drawing large audiences. These with the Indian, Chinese and South American pavilions, erected on the Champs de Mars, added much to the picturesque effect, by contrast with the great masses of the main buildings, and showed how much more attractive an Exposition can be made by scattering some of its features into isolated buildings than by concentrating all under a few great roofs.

Along the Quai d'Orsay the buildings were mainly for utility and chiefly contained food products. This was an instructive but a wearisome portion to go over.

The Esplanade of the Invalides (outside of some large buildings erected for the war department) was chiefly given over to an exhibit of native life in the French colonies, dependencies, and in some of the far eastern nations. For this purpose dwellings, bazars, and temples were erected in

exact counterpart with those of the country illustrated, and they were inhabited by groups of natives, clothed in their ordinary costumes, plying their ordinary avocations, or going through their religious ceremonies.

This presented an exotic, rude and odd appearance which attracted great and curious crowds. It is clearly a feature to be repeated in future expositions, in order to show the people of one country the manner and appearance of those of other countries, and a "street of the nations" displaying their foreign architecture and modes of life, must always prove a powerful attraction.

But it is time to resume the account which I began to give you of the engineering of the exposition.

About two months after the awarding of premiums for the general designs July 28, 1886, the working organization of the exposition was promulgated. It consisted of a "general commissioner" who was the Minister of Commerce, and of three "director generals" who reported to him. The first was in charge of the works of construction, the second in charge of operation, and the third in charge of finances.

The Director General of Works was M. Alphand, whom doubtless, many of you know by reputation, as one of the leading engineers of France, and who has been for very many years the Chief Engineer of the City of Paris. He was placed in charge of all works of construction, as well as the subsequent removal of the buildings, and acted also as organizer of public festivals, as well as chief of the medical service.

He organized the various engineering and architectural bureaus in August, 1886; called around him a large and able staff, and vigorously set to work.

His plan was to take hold of the easiest things first, in order to get them done and out of the way. Thus, although it took about one year to perfect the final plans, the foundations for the Miscellaneous Industries sheds were begun in March, 1887 (seven months), while other buildings were still being planned. The results of this planning can best be shown by describing to you the main buildings.

THE MAIN BUILDINGS.

It has been well said that the Paris Exposition was more remarkable for the general effect of its buildings than for that of their contents. The latter to be sure, were arranged with exquisite taste, and comprised exhibits of all industries, and of almost all the productions of nature and of man, but they presented nothing strikingly novel—nothing which had not been seen before, while the buildings themselves marked a great advance in construction, and perhaps the evolution of what may prove to be a new style of architecture.

Iron construction has hitherto been treated by engineers and architects, either in an imitative or in a purely utilitarian way. Either the front of iron buildings was moulded to resemble stone, and the character of the material used carefully concealed, or else it was shown (as in the interior of railway buildings), by great trusses which, although scientificially correct, produced in perspective a painful impression on the eye, through the cob-web intermingling of their many lines. These defects in design have

been recognized for several years, but yet only few and tentative efforts were made to give artistic effect to such constructions, while boldly leaving apparent the material of which they are composed.

One such effort, and as I think, a successful one, will occur to you in the passenger station of the Pennsylvania railroad at Philadelphia, while the French have made a good many more, notably in some of the constructions for the exposition for 1878. For that of 1889 they boldly decided that all the main buildings should be of iron, and some of their ablest architects devoted their best talent to making them things of beauty.

This was accomplished by very simple means. In the first place no attempt was made to disguise the material which was employed; where a support was needed, an ordinary latticed post was placed, composed of plate, channel, and angle iron. When it formed part of the outside of the building, the inside of that post was filled in with brick work, or with slabs of terra-cotta, which were thus set back of the latticed bars and angles, and which by their soft yellows or browns presented a pleasing contrast to the pale blue with which the iron work was painted. The wall pannels between these posts were built of brick, plain or enameled in bright colors, and ornamental medallions and escutcheons were inserted wherever decorative effect was desired.

Inside of the buildings, what we term here as the "French truss," was on this occasion discarded, and the spaces were spanned by riveted lattice girders, to which an artistic effect was generally given by curving the lower member at the springing from the post. In some cases both posts and roof were composed of two continuous curved lattice girders, springing from the ground, and resting against each other at the apex of the roof. This was notably the case in the grand Machinery Hall, 1,378′ long and 475½′ wide, with a clear span of 364′ between the centres of the semi-cylindrical bearings at the floor line. I need not tell you that this is the widest span of roof ever erected, and that this noble building was well worthy of the grand prize which it received, as the most novel and remarkable object in the exposition.

Curiously enough this great roof was not shown in the original plan of its author which received one of the prizes. It had long been on the mind of its architect, M. Dutert, whose official title, by the way, was that of engineer, but he judged that its boldness would cause his plan to be thrown out altogether as visionary. He therefore simply indicated the general outlines of Machinery Hall, within which were rows of dots which might be imagined to be intermediate posts, and after his design had been accepted, he sprung the great roof on the administration. At first the management was appalled, but when calculations of strains showed that the thing was feasible, the desire to perform a great feat overcame the objections as to expense, and the work was decided upon. You will find the details of this great roof and the method by which it was raised as well as those of the other buildings, in the number of London *Engineering* of the 3d of May, 1889. The foundations were begun July 5, 1887, the erection of the iron work began in April, 1888, and was completed October 1, 1888. The cost of this building, as will hereafter be shown,

was about $2.18 per square foot of space covered, which, while surprisingly small, and less than an ordinary wooden cottage in this city, was yet about two and a half times that of the next portion of the main buildings, which is known as the Miscellaneous Industries group.

This group was designed and built by M. Bouvard, an architect and engineer, and comprises the most beautiful architectural object about the Exposition, in the central dome, which has been shown to you, as well as a very brilliant effect along the three sides which front on the central garden.

This group, as you will perceive from the picture (No. 2), consists of a series of iron sheds of about 82′ span, which, with the central main transept that terminates in the grand dome, cover a block of about 1,378′ by 685′. Beyond this begins the central garden, flanked on either side with further series of iron sheds pertaining to the Miscellaneous Industries group, the whole cost of which was only 84 cents per square foot. The foundations for the sheds were begun in March, 1887. Their erection was begun the following May, and was completed in October, 1887, while on the central dome the foundations were begun in March, 1888; erection commenced June 1, and was finished October 15, 1888.

The next division or group of the main buildings was designed and built by M. Formige as architect and engineer. It consists of the Fine Arts palace on one side of the garden and the Liberal Arts palace on the other, each being flanked by the transepts connecting them with the Miscellaneous Industries group. The cost was $3.09 per square foot, the buildings, however, being practically two stories in height. The foundations of these buildings were begun in March, 1887, the erection commenced in April, 1888, and was completed in November, 1888.

The following shows the dimensions and cost, so far as now known, of these three groups of the main buildings:

Building.	Length.	Width.	Sq. ft.	Aggregate Sq. ft.	Est. Cost.	Cost per Sq. ft.
Machinery Hall......	1,378 ft.	475½ ft.	655,239	655,239	$1,4-6,208	$2.18
Miscel. Industries...	1,378	685	943,930			
Miscel. Industries...	440	330	145,200	1,234,330	1,027,295	0.84
Miscel. Industries...	440	330	145,200			
Fine Arts.............	738	275	202,950			
Liberal Arts.........	738	275	202,950	486,540	1,504,209	3.09
Transept Rapp......	384	105	40,320			
Transept Desaix.....	384	105	40,320			

Just beyond the limits of this group of buildings there stands that most complete triumph of iron architecture, the Eiffel tower, with its graceful lines stretching 1,000 feet into the air. It is now so well known and has been so much written about, that I shall not waste your time by describing it, but the curious among you may read with a smile the vigorous disparagement which was being printed concerning it, only three years ago, in the accounts of the competition in designs which I have presented to the Society.

The weight as you know is 7,300 tons, and the latest statement of the cost which I have seen is as follows:

Excavations and masonry	$ 118,485
Metallic construction	1,079,662
Wood work	38,752
Roofing, lead and zinc work	47,336
Flooring	15,718
Joiner work	6,869
Glazing	36,449
Ornamenting	51,228
Painting	31,710
Sundry contingencies	38,045
Office expenses	38,564
Total	$ 1,502,818

which is understood to have been almost wholly recouped by the fees collected from visitors during the exposition.

One great difficulty which faces any future exposition will be to find some equally popular attraction, without copying M. Eiffel.

Now, the question naturally arises how you can best avail of the foreign experience, if called upon to carry out similar works in this country. I will give you such hints as have occurred to me, and you will take them for what they are worth.

In the first place, it should be understood that the exposition management furnished, inside of the buildings, only the walls and roof. The floor consisted of the bare ground, and had to be covered by the exhibitors themselves, as will be more fully explained hereafter. This feature may well obtain in future exhibitions. In the next place, architectural display may be confined to a few principal features, if the location selected admits of it. There should of course be some handsome facades or domes to arrest and please the eye, but the remainder will in any event be ranges of low sheds, and it is both difficult and costly to produce much effect with these. These ranges of sheds are chiefly seen from the inside but experience proves that inside of the buildings the public is chiefly concerned with the exhibits, and pays but little attention to the architecture.

I think myself that the Machinery Hall in Paris would have been nearly as effective inside if it had consisted of a series of sheds instead o one great roof. In point of fact there were inside of it four rows of columns carrying the shafting and traveling bridges, which produced much of the interior effect of intermediate columns. The cost of that building might have been cut down one half without detriment to the exposition as a whole.

The Fine and Liberal Art Palaces were very beautiful, but here again money might have been saved by making shorter spans than those of the central roofs of 168 feet; this, especially in view of the fact that the interior of these buildings was cut up into smaller rooms in order to separate the pictures or the various divisions of the liberal arts.

My own judgment, therefore, is that good architectural effects can be produced, and a future exhibition housed at less cost than was that at Paris. Except the picture galleries, which ought to be in thoroughly

fire proof buildings, I should estimate that the exhibits ought to be housed at a cost of about $1.25 per square foot, or say $55,000 to $60,000 per acre.

One very important problem is going to be how to dispose of the second hand material after the close of the exposition. Some of you know what the experience was at the Centennial at Philadelphia. The French, taught by the sore experience of 1878, after which the old materials were sacrificed, have solved the difficulty this time by deciding to retain permanently the Machinery Hall, the main transept and central dome, as well as the Fine Arts and Liberal Arts buildings, but it is not on every location that this course can be resorted to. The principal difficulty arises from the fact that when the buildings are torn down, the market is glutted with materials for which there is only a limited demand. This suggests that instead of making plans to employ the usual forms of iron posts and iron trusses, the designs might be made to employ forms of the material in common use, and for which there is a constant and large demand, so that they may be obtained quickly and be readily resold. Thus the posts might be of cast-iron water pipes, or of standard forms of rails, clamped instead of riveted together, and I may say here, that some of the pipe manufacturers of France exhibited very beautiful effects obtained in that way. Some of the shorter trusses may similarly be composed in part of rails or gas and wrought iron pipes, the whole may be made glorious with paint, and when the exposition is over, the various parts may be unscrewed, taken apart and thrown into the market.

If some such method be adopted, there is yet time enough to open an exposition on the first of May, 1892. There is none to waste, but in the intervening time it is possible to advertise for plans, to perfect and to work them out, to contract for and obtain the materials, to erect the buildings and to arrange the exhibits.

THE ARRANGEMENTS OF EXHIBITS.

One remarkable feature in the management of the Exposition was the way in which the services of large numbers of citizens were enlisted without other reward than public approbation, and possibly the hope of a decoration.

Several thousand persons did gratuitous work of this kind.

First, there were the "departmental committees" aggregating some 4,300 members, whose business it was to seek throughout France whatever was best worth exhibiting, to persuade possible exhibitors to undertake the expense, to distribute circulars and applications for space, and to have the latter forwarded to headquarters. These were the providers; they scoured the country for exhibits.

Second, there were the eighty-four "Committees of Admission" (one for each class) with some 1,700 members. Their business was to canvass carefully the applications, to reject all that did not propose creditable exhibits, and to examine applications for space, so as to procure the finest display. These were the auditors or comptrollers who culled the best that was offered.

Next there were the "Committees of Installation" who were largely com-

posed of the same persons who had previously acted on the committees of admission, and who aggregated about 1,300 in number. Their duty was to allot among accepted exhibitors the space apportioned to each class and to supervise the arrangement of the exhibits. All these committees served without pay.

As has already been stated the management of the Exposition only furnished the roof and sides of the building. The portals, the floors, the interior decorations, the screens and the show cases, were at the charge of the exhibitors, as well as the cost of arranging and displaying the goods. The supervision of all this rested with the "Committees of Installation," one for each class. They engaged, subject to the approval of the management, the necessary architects and engineers (chiefly engineers, I may say), and these prepared the designs and plans of installation in consultation with both the exhibitors and the general administration.

Then estimates of the cost were made, and care was taken to make these more than ample, as previous experience had shown that it was easier to collect one dollar in advance of the opening than one cent for deficiencies afterwards. Next the estimated expense was assessed pro rata, and collected from the exhibitors, and the work was done with the funds so obtained, under the charge of the architect or engineer approved for each class.

These Committees of Installation were expected to organize and to begin their work, not later than the 15th of February, 1888. So carefully and prudently did they manage, that in the final outcome there remained some surplus funds in almost every class, and these it was proposed to return pro rata to the various exhibitors, after the final settlements of the accounts.

This method, it will be perceived, ensured unity of action and economy, besides securing experience and taste in the arrangement of the display.

The results were surprisingly good, and foreigners, Americans especially, were delighted with the effects produced. The most common and inelegant articles, which in an Anglo-Saxon Exposition would probably have been piled up in heaps, were arranged by the French taste into beautiful groupings, and the artistic sentiment and training of the Latin races were everywhere apparent. Thus, to take a few instances at random, some wine growers, instead of exhibiting their bottled goods on shelves, as would seem right and proper, arranged them in triumphal arches across the passageways. A manufacturer of picks and shovels arranged them in a trophy, like pieces of old armor. A maker of tubes built elegant fluted columns of them, while with the finer goods which lend themselves to decoration, the effect was simply dazzling.

In this respect there was a great contrast at Paris between the French, Belgian and Italian sections, and those of English speaking countries, and it is believed that it will be very difficult in this country to produce as brilliant effects, because of the lack of that artistic instinct which is alone conferred by the training of several generations.

If it be desired to produce similar effects in this country; to repeat here what so greatly delighted foreign visitors in Paris, and to reveal to

the masses of our own people what can be done for the pleasure of the eye, I verily believe that it will be advisable to bring over some French architects to supervise the arrangement of our exhibits.

The rest of the planning and work we can do ourselves. We can do it too within the time at command, and I shall be well pleased if anything which I have said to-night proves to be of assistance to such of you as may be entrusted with the work.

EXPERIENCE IN THE CONSTRUCTION OF GAS-HOLDER TANKS.

By G. A. Hyde, Member Engineers' Club of Cleveland.

[Read June 10, 1890.]

Every engineer in the practice of his profession, encounters conditions which he must consider and adjust, according to his personal knowledge and ability, without an experience in a similar case or without advice or council of others.

The experience of one engineer may to a considerable extent be the duplicate of many others, and yet, the relating of ones experience may possibly inure to the benefit of others or at least may invite criticism or discussion and call out the best thought and experience of many.

We are associated together for mutual improvement and exchange of thought and ideas and I shall venture to offer for your consideration a short description of "my experience in the construction of gas-holder tanks."

In the year 1867, it became necessary to construct a gas-holder tank for the Cleveland Gas-Light and Coke Company, at the N. E. corner of Main and Spring streets. The particular or unusual conditions were, a location in a side hill with a bank 50′ high above the level assumed for the top of the tank.

Previous to that time I had had neither practice nor information to aid in determining the better method of procedure, but it was very apparent that unusual precautions must be taken to insure the safe and successful construction of the tank without making an unnecessary amount of grading outside of the tank walls.

Having determined the surface grade line, the excavation was made on that level to cover a space 15′ outside of the proposed tank wall.

The excavation for the wall was made in a circular trench in a manner similar to the present common method of excavating for the construction of sewers, the lines of the circles being in straight segments of about 16′ in length, with a space of 10′ between the outer and inner circles. The two lines of sheet piling were kept apart by strong stringers and

braces to insure against the possibility of the sliding in of the adjacent high bank.

The sheet pilings were 14′ long and the excavation for the complete circle was first made to that depth. Then an offset of one foot was made inward from each of the circles of sheet piling and the sheet piling set and excavation carried on to the farther depth of 18′ or 4′ below the bottom of the second course of sheeting which were also 14′ long. No sheeting was required for the remaining 4′, as the earth was of hard blue clay and would stand long enough to allow the placing of the footing and building of the wall to that height.

As the construction of the wall progressed, refilling of earth was made on each side of it, and the sheet piling withdrawn as fast as safety to the wall would permit. When the wall had reached a point about 3′ below the ground, line work on it was suspended and the wall was covered with earth to the surface of the ground and allowed to remain as a protection from frost through the winter and permitting the cement to harden before the excavation was made from the inside of the tank. This excavation was commenced in the spring and all the earth removed except a mound, a frustrum of a cone 15′ in height and 90′ in diameter at the base, and 48′ at the top.

The whole surface of the bottom and the cone was covered with a layer of cement concrete 6″ in thickness.

The dimensions of the tank are as follows.

Inside diameter..........	103 feet.
Inside depth	30½ feet.
Thickness of wall................	36 inches.

At 10 points there were pilasters or buttresses 4½′ square joined to and made part of the tank wall to support the same number of columns to guide the rise and fall of the gas-holder.

The footing or foundation course was made of cement concrete 5′ wide and 1′ thick.

In three similar tanks constructed subsequent to the aforementioned the footings were of stone, 6′ wide, and 10″ thick, bedded and jointed in cement mortar. The walls are 36″ thick the entire height, and the whole enclosed in a house 64′ high resting on the tank wall. Twenty pilasters 4′ square were built into the tank walls, to support the pilasters of the house on which were secured the guide rails for the holder.

In 1872 I was called to construct a gas-holder tank for the Titusville Gas Co.. at Titusville, Pa., under the particular and unusual condition of superabundance of water in the earth. The location was a level piece of ground in the valley adjacent to a creek and the excavation coarse gravel and small boulders. The excavation was made 12′ below surface of ground, 6′ of which was below the bed of the creek. To make the excavation and construct the tank wall it was necessary to raise 8,000 to 10,000 barrels of water per day. The method of procedure to accomplish that end was as follows:—A well was sunk outside of the space to be occupied by the tank and to a depth sufficient to drain the earth below the required depth of the tank wall. After the excavation had been made to grade of the bottom of the footing a ditch was dug outside

of the line of footing deep enough to receive a line of sewer pipe ranging in size from 10″ to 4″ in diameter, running both ways from the well to the opposite side of the tank. The joints were left open to permit the free access of the water from the gravel. Then followed the laying of the footing and the building of the tank wall, during which time the pump was kept in constant operation.

A 10″ iron pipe was laid under the footing at a point opposite the well through which to convey the water collected on the inside of the tank wall.

Another row of sewer pipes ranging in diameter from 10″ to 4″, was laid along below and near the inner line of the footing and connected to the iron pipe leading to the well. From a few points inside of the tank where abundant springs appeared, a line of 4″ sewer pipe was laid to the larger sewer pipe, by which means all water appearing was safely and surely conveyed to the pump well.

The whole surface of the bottom of the tank was then covered with cement concrete to the depth of 8″, but leaving a vent hole 10″ in diameter at the junction of the sewer pipes and the iron pipe to permit the inflow of water into the tank in the event of the stopping of the pumps, and the outflow of the water from the well.

When the concrete was completed and properly set the holder was built and then a plate was secured to the vent hole and covered with cement mortar. The water from the pump was then turned into the tank until filled to the top, completed the undertaking.

ADDRESS OF W. R. WARNER, PRESIDENT OF THE CIVIL ENGINEERS' CLUB OF CLEVELAND, AT THE ANNUAL BANQUET, MARCH 27, 1890.

Gentlemen of the Civil Engineers' Club of Cleveland:

The present occasion marks the tenth anniversary of the organization of this Club. These have been ten years of wonderful development in the science of engineering, and the members of this Club have done their share in solving the problems presented.

Our membership is made up of Civil Engineers in the broadest usage of that term—engineers in civil life, in distinction from military engineers or engineers in Government military service. So we have Railroad Engineers, Topographical Engineers, Bridge Engineers, Mining Engineers, Hydraulic Engineers, Mechanical Engineers, Electrical Engineers, Architects, Scientific Investigators, Chemists, Astronomers, and Professors in our Colleges.

Our first President, Colonel Paine, was chosen to the high position of Chief Engineer of the West Shore Railroad, and on its completion took

the position of Vice-President of the Philadelphia Company at Pittsburgh, which office he now holds.

Colonel Wilson, our second President, was called to Washington as Superintendent of Public Buildings and Grounds, where, by his native civil courtesy, he also engineered the social events of the White House during the Cleveland Administration. At the beginning of the present administration at Washington, Colonel Wilson was appointed Superintendent of the West Point Military Academy, which position he now holds.

Another ex-President of our Club, Mr. J. F. Holloway, was called to a larger field, in the metropolis of our country, where he is Consulting Engineer of the largest hydraulic works in the world. Two of our members, Prof. A. A. Michelson, and Prof. E. W. Morley, have, by their keen analysis, reached out and grasped the Sun, and measured the velocity of light, and determined the distance of our earth from that luminary. They take the same ray of light after its journey of over 92,000.000 miles from the sun to the earth, and accurately divide it into wave lengths, 50,000 of which are required to make a single inch. We are thus given an exact standard of linear measure, which need not be preserved in the archives of the nation, for nature's laws preserve it for us, and it cannot be destroyed by fire or war.

Another of our members, studying from his little observatory on Case Avenue, by his far reaching mathematics, traces back the paths of the planets for many thousands of years, proving ancient history true; and demonstrating the facts of the earliest ancient eclipses, which occurred more than three thousand years ago, thus bringing order out of chaos regarding the Moon's motions, and solving problems which have vexed astronomers ever since astronomy became an exact science.

The Central Viaduct in this city was designed and built by members of this Club. It is 4,000′ long and 100′ high, costing, including right of way, $875,000, making it the most economical structure of its kind in the world.

Time will fail me to make further mention of the important engineering works being developed by our own members, but the work of the profession during the few years past surprises us, and leads us to wonder what worlds are left for engineers to conquer.

The East River Bridge with its beautiful catenary curves and faultless symmetry, is still the monarch of its class, while for grandeur and boldness in design and construction, the cantilever bridge near Edinborough, better known as the Forth Bridge, surpasses all others. Its three spans of over one-third of a mile each, were built without staging, or any outside support, by extending beam after beam and section after section out over the water at a height of three hundred feet, until they met and were joined in the centre. Our President-elect gave us at the September meeting an interesting description of this great work.

The year has witnessed the completion of an engineering work of the greatest popular interest, the Eiffel Tower at Paris, but its altitude of nearly 1,000 feet, will probably soon be surpassed by one in London, and possibly by a similar structure in our western metropolis.

The Digging Engineer has work in hand no less important than the Building Engineer, for no sooner was the Suez Canal a *success*, than others of equal importance and greater difficulty were planned. The Panama Canal has received a check in its progress, and some of its problems seem well nigh insurmountable, but its neighbor the Nicaragua Canal promises early completion, as also does the Manchester Ship Canal.

In boring tunnels the engineer has achieved some of his most marked successes. The Hoosac Tunnel, four miles long, completed twenty years ago, was the wonder of its time, but the experience there gained has been followed up until the Engineer has pierced the Alps, joining France and Italy by the Mt. Cenis Tunnel, seven miles long, and connecting Italy and Switzerland by the St. Gothard Tunnel, nine miles long.

Our country will soon be connected with the Queen's Dominion by a tunnel at Sarnia, and the North River Tunnel promises in the near future to join New York and Jersey City.

Engineers have already prepared feasible plans for a tunnel under the English Channel, and also a cantilever bridge across it. The great problems which at present prevent the joining of England and France by one of these engineering ties are purely political, and it is hoped that the Court of Public Opinion will soon demand their solution, at which time the Engineer will take up the work and quickly complete it.

The improvements in transportation have brought our western products to the eastern states more cheaply than they can be raised in New England, and as a result the New England farms are being left to be covered again with forests, and the industries of that section of the country are completely changed from agricultural to manufacturing. Mr. Leland's calculations prove that a piece of coal 1¼″ square weighing 1½ ounces will transport one ton of merchandise one mile. Our steamships of thirty years ago consumed 14,000 pounds of coal for each ton of freight transported across the ocean, while our modern racing steamers with their triple expansion engines consume only 330 pounds of coal per ton of cargo, and our most economical freight steamers carry a ton of freight a distance of two miles by the consumption of a lump of coal weighing one ounce and will carry a ton across the ocean by consuming 100 pounds of coal.

Ours truly, is an Engineering Age and all natural forces are brought into subjection to man's will. Nature's laboratory has for geologic ages been at work for the age in which we live, and now she opens her treasures, and the world is supplied with coal and oil and gas. Ever since Franklin drew lightning from the clouds keen minds have been at work to harness the mysterious force and make it do man's bidding; but only within the memory of those present has it surrendered to man's rule and become his willing servant. He has taught it to do his writing, and his talking across continents and seas, and it has beaten Ariel's record by "putting a girdle round the earth" in less than "forty minutes." He has taught it to illuminate to almost solar brilliancy, his streets, his halls, and his homes; to furnish power for his mills, and his railroads; to smelt and weld his most refractory metals; and become his general business and household servant.

In the Science of Engineering we have the greatest encouragement for the most earnest work, and we have every reason to believe that victories equally important will be won by the energetic thinking investigating members of our profession.

The work of the Civil Engineers' Club of Cleveland brings us together for mutual interchange of thought and we all can grow richer and stronger by it.

In beginning the second decade of our club life and work let us be encouraged by past victories and press forward to greater ones in the future.

THE FILTRATION OF NATURAL WATERS.

By Thomas M. Drown, Member Boston Society Civil Engineers.

[Read January 15, 1890.]

In the study of the subject of filtration of water for drinking purposes, we shall arrive at no clear and valuable ideas unless we distinguish sharply between mechanical filtration, which deals only with the interception and retention in the filter of the solid particles suspended in the water, and filtration combined with the oxidation of organic matter,—that in solution, as well as that in suspension in the water. This latter process—the purification of the water by the oxidation of its organic contents—can be accomplished only by *intermittent* filtration, the former—the mere removal of the solid particles in the water—may be accomplished by *continuous* filtration, as practiced in many large cities in Europe.

When we speak of the purification of water by filtration, we mean in a general way, that a water is thereby rendered fit to drink which was unfit or unattractive before it was filtered. The change effected by filtration may be simply the removal of vegetable or earthy matters, whereby the water is made more palatable and more attractive in appearance, or it may be more radical in converting water which was positively harmful into a good drinking water. Widely different in action as are the two systems of filtration, the intermittent and the continuous, yet it is possible by both systems to improve the quality of a bad water.

In the system of continuous filtration, in which there is little or no change made in the dissolved organic matter, it might at first thought seem as if there could be only imperfect purification; but it must be borne in mind that it is possible in this system to remove in great part even those very minute organisms, the bacteria.

The germ theory of disease furnishes us with the simplest explanation of the way in which water does harm, and if we can, by simple mechanical filtration, remove the harmful germs from the water, we have effected a true and efficient purification of that water, whatever may be its chem-

ical composition. Let us push this idea a little further. If we take as the basis of our theory of harmfullness of water that disease is caused by it only when micro-organisms are present in it, then, if we could by the continuous filtration of sewage remove absolutely all the germs which it contained leaving unchanged its other characters—appearance, taste, odor &c.—this sewage would be perfectly safe to drink. To put the matter in another form, a sterilized water or sewage has no possibilities of producing disease except so far as as it may contain saline or other substances which may produce derangements of the system in the same way as would a drug—a dose of salts or of senna. It is foreign to my present purpose to consider whether our knowledge at present justifies this position, but it is important to bear it in mind in judging of the efficiency of filtration.

When water is said to be well, or moderately well, or completely purified by filtration we cannot know what is meant unless we know what is the standard of purity implied. Is it simply the removal of color, odor and suspended matter; is it chemical purity, meaning thereby the absence of unoxidized organic matter; or is it bacterial purity, or freedom from germs? Again, what shall we say of water of high chemical purity, with high bacterial contents: or what of a water with few or no bacteria which contains considerable organic matter capable of undergoing change?

Intermittent filtration is capable of giving water free from organic matter and free from germs; continuous filtration, if conducted very slowly, is capable of giving water free from bacteria, without odor and color, but which may contain much dissolved organic matter. Intermittent filtration effects the oxidation of the organic matter in solution as well as that in suspension; continuous filtration has little or no effect on the organic matter in solution.

After laying such stress on the removal from water of bacteria, it sounds like a paradox to say that purification both by intermittent and continuous filtration depends on the presence in the filter of bacteria in enormous number, and that without them the purification would in both cases be impossible.

The idea is not a new one that the bacteria of decomposition are benign and useful organisims which break up organic matter, rearrange its atoms and convert it into mineral matter so that it may again serve as food for plants. If we keep away the bacteria from a mass of dead organic matter it undergoes no change whatever. All processes of decay of organic matter are absolutely dependent on the presence of these micro-organisms, which, so far as we know, have no other than a beneficent role to play in nature. I say this is now a matter of common knowledge and one is therefore not unprepared to hear, that in the purification of water by intermittent filtration the ground or sand upon which the water is poured is full of bacteria, in fact, that it is the design of the process to cultivate them and have as many of the micro-organisms in a cubic inch of ground as possible.

If one pours over a column of clean, bright, sand, free from bacteria, impure water, as sewage, it will flow out about as bad as it entered the sand. But if it is poured over a column of sand in which septic bacteria have been cultivated, so that the sand may be said to be fairly reeking with

bacteria by the million, the water may flow out as pure (organically) as spring water. But even in continuous filtration, where there is little or no oxidation going on the bacteria are, according to Piefke, (the engineer of the Berlin water works,) the efficient agents in removing the suspended matters, including the micro-organisms in the water. To this subject we will return later; let us first briefly study the nature of oxidizing or intermittent filtration on the typical polluted water, namely sewage.

Sewage is a substance which contains all of its nitrogen in the unoxidized form. Its principal ingredient is free ammonia; it also contains considerable, (but a much less amount, usually,) organic nitrogen, or albuminoid ammonia, but of nitrous or nitric acid it contains none. When sewage is exposed to the air in mass, oxidation goes on very slowly, because it can only get air from its surface; when it flows out into streams, the oxygen dissolved in the water of the streams quickly oxidizes the ammonia, and we find in the water a short distance below the entrance of the sewage, nitrites and nitrates abundantly. When the sewage is exposed to the air in very thin layers, as when a porous material like sand is moistened with it, oxidation goes on with great rapidity. It was until recently considered that this oxidation was a direct chemical combination of the elements of the organic matter with the oxygen of the air, or the oxygen dissolved in the water, but we now know that nitrogen is not oxidized by the direct contact of decomposing nitrogenous matters with air, unless bacteria are present, and the inference seems a fair one that the greater the number of bacteria the more rapid the process of oxidation. Sewage itself usually contains hundreds of thousands of bacteria to the cubic centimeter which are dormant until air gets access to it. If sewage is preserved out of contact of air, the bacteria of decomposition will in time all die.

The experiments of the Massachusetts State Board of Health on the purification of sewage by intermittent filtration which have been carried on at Lawrence for the past two years, under the direction of Mr. Hiram F. Mills, the engineer member of the Board, have added largely to our knowledge of the conditions governing the purification of nitrogenous organic matter. Here are large tanks, $^1/_{200}$ of an acre in surface, filled with different materials—coarse sand, fine sand, river silt, muck, garden soil, clay, &c. to the depth of five feet, on which is poured from day to day, sewage in known amount and of known composition. The effluent water from this sewage filtration is collected, measured and analysed and the precise amount of purification determined. The result of two years work at this station will shortly be published in the Report of the Board now in press. I will at present give one or two of the facts that have been there developed. The purification of the sewage means the complete oxidation of all its organic ingredients both in solution and in suspension, the carbon to carbonic acid, the hydrogen to water and the nitrogen to nitric acid. The filtering materials best adapted to the purpose are those which are fine enough to retain considerable sewage in their pores and also plenty of air at the same time.

The body of porous material is, when in good working order, a very delicate machine. It must be coaxed up to its highest efficiency by grad-

ually increasing the amount of sewage. This means, in all probability that we must develop in the pores of the sand an immense number of bacteria to be constantly on hand in the different layers to attend to the sewage as it reaches them. During the first winter there was no nitrification in these tanks and consequently no perfect purification, but on the advent of spring, when the temperature of the effluent water reached 39° F. nitrification began and has continued ever since, the cold weather of the second winter failing to stop it.

The tank which has given the best results, that is, a good purification of the largest quantity of sewage for a long period is filled with coarse mortar sand, most of the grains of which average about 0.06 inch in diameter. This has given an effluent day after day organically as pure as many drinking waters, when receiving sewage at the rate of nearly 60,000 gallons per acre per day.

One would naturally ask why is not this the ideal system of purification of all surface waters, even those that are not polluted by drainage of any kind but which contain much vegetable suspended matter, and have, in consequence, sometimes, a bad odor; or waters which are unattractive in appearance by reason of dissolved coloring matter?

One of the tanks of the Lawrence Experiment Station, has filtered Merrimack water intermittently for more than two years at the rate of 300,000 gallons per acre per day. The filtering material consists of 3′ 8″ of coarse and fine sand and fine gravel; 10″ of yellow sandy loam, and 6″ of brown soil in the same position as found on the river bank. During the day the surface of the sand is generally covered with a few inches of water, but at night and on Sunday air gets access to the sand. The following figures give the composition of the filtered water during last December, compared with the Merrimack water applied:

	MERRIMACK RIVER WATER. Parts per 100,000.	FILTERED WATER. Parts per 100,000.
Turbidity	very slight.	none.
Sediment	very slight.	none.
Color	0.35	0.0
Odor	faintly vegetable.	none.
Total solids	4.2.	3.5.
Loss on ignition	1.6	0.9
Free Ammonia	.0015	.0005
Albuminoid Ammonia	.0127	.0059
Chlorine	.18	.18
Nitrogen as Nitrates	.0124	.0191
Nitrogen as Nitrites	none	none.

The water is free from microscopic organisms, and the bacteria rarely exceed 10 or 20 per cubic centimeter, while the water applied has generally a few hundred. During the two years that this tank has been in operation the surface has not been cleaned or disturbed in any way.

The slow rate of filtration (being only about one-half an inch an hour per square foot of surface) is due to the considerable amount of very fine material contained in the soil and loam.

But one must bear in mind, in connection with the rate of filtration, that the thoroughness of the purification, meaning thereby the oxidation of the organic matter, is much greater in intermittent than in continuous filtration.

This system of intermittent filtration for natural waters has never, I believe, been carried out on the large scale, although the possibility of its being practicable in some localities has been discussed. It is the system that nature suggests, for it is intermittent filtration which supplies the springs which furnish the ideally pure and perfect drinking water. In the report of the Massachusetts State Board of Health to the Springfield Water Board with regard to the purification of the water of its Ludlow reservoir, which contains an immense growth of blue-green algæ, Mr. Stearns, the chief engineer of the Board, suggested that surveys be made to discover, if possible, suitable ground, conveniently situated. on which to pour intermittently the water of the reservoir and to collect it again at lower levels in wells and springs. It is probable that continuous filtration would be inapplicable to water of this kind, for the jelly-like masses which are secreted by these algæ would probably close the pores of the filter in a very short time. With intermittent filtration the deposit of organic matter in the pores of the sand would dry out or become oxidized when the ground was more or less dry.

It has been to many a difficult matter to explain how filters working continuously, and constantly covered with water could intercept objects so much smaller than the spaces between the particles of sand. It was easy to imagine that some of the minute suspended particles might be caught between the particles of sand, but that practically all the suspended matter, even the minute bacteria, could be removed in a good-working filter, seemed to indicate that the efficient working of a filter depended on the fact that it became nearly clogged on the surface by the algæ and other matter which held back even the smallest objects. But if this were the case it would save time to use a finer sand at the outset which experiment shows will not accomplish the purpose.

Piefke has given us the clearest conception of the action of sand filters in removing the suspended matters including bacteria from surface waters. The chemical effect is very slight, as might be supposed when one reflects that the duration of the passage of the water through the sand seldom, if ever, exceeds five and one-half hours, and, since the filter is kept constantly covered, there is no oxygen present but that dissolved in the water. But the mechanical effect in removing suspended matter—mineral and organic—is very great. The Spree water, which forms part of the supply of Berlin, contains as high as 100,000 bacteria per cubic centimeter at times, and the number in the filtered water rarely exceeds 100, that is, the reduction of bacteria may reach 99.9 per cent. The thickness of the sand layer is generally from 2′ to 3′ and this rests on a layer of coarser gravel, which is without any effect on the filtration. The size of the sand is seldom finer than one-fiftieth of an inch, which leaves channels between the

grains that 500 micro-organisms could pass abreast. Smaller still are the particles of clay which give a milkiness to water, and yet when one of these sand filters is working well, both clay and bacteria are held back in the sand.

It takes a new filter about two weeks to get to its maximum efficiency and if the sand be first carefully cleaned and sterilized by heat, then it takes much longer, many weeks, before the filter works well.

On examining with the microscope the surfaces of the particles of sand when the filter is in perfect working order, they are found to be coated with a greasy, slimy substance which is a mass of bacteria jelly. Piefke found in a kilogram of sand taken from the surface of a filter 5,600,-000,000 bacteria; just below the surface 734,000,000 and at the depth of a foot 92,000,000. These numbers he says are far below the truth, because of the difficulty of cleaning the particles of sand thoroughly. It is to this coating of bacteria jelly that Piefke attributes the efficiency of these filters, and until the jelly forms in sufficient amount to completely envelope each particle of sand, the filters work imperfectly. This then is his explanation of the fact that minute micro-organisms and particles of clay of infinitely smaller size than the channels in the sand are stopped in their passage through it—they are simply caught in this slimy coating and cannot get further.

A filter of this kind is, like that used in intermittent filtration, a very delicate instrument and it is very easy to disarrange it. Disturbance of the sand or suddenly increasing the pressure of the water may have, as a consequence, a rush of bacteria into the filtered water. Quite regular working is an essential condition of success. The rate of filtration is on an average only four inches vertically an hour, so that in the passage of the water through the sand, one-third of which is interstitial space, its rate is three times as great, or twelve inches an hour, and the sand layer being two feet thick, the water is in contact with the sand only two hours. In very turbid waters or waters very high in bacteria the filtration is often decreased to one-half this rate or even less, and in comparatively clear water, with low bacteria, the rate may be doubled. The working of the filters in Berlin is governed entirely by the number of the bacteria in the filtered water, this being the simplest way of judging of the efficiency of their working. One hundred bacteria per cubic centimeter in the filtered water is considered a good result on the Spree water, which contains always many thousands. To give practically sterile water would require a diminished rate say to one vertical inch an hour, which would be impracticable without enlarging the filtering plant.

The surface waters used to supply London from the Thames or the Lee are filtered by the method of continuous filtration, a surface of one hundred acres being required for the purpose. The thickness of sand differs with the different companies supplying the city with water, from two feet at the East London and Grand Junction Companies to four and a half feet at the Chelsea Company, and the rate of filtration per hour in imperial gallons per square foot of filtering surface is two and one-sixth with the Lambeth Co., to one and one-half gallons with the Southwark & Vauxhall Co. Two and one-half gallons, or five vertical

inches an hour (which is seldom attained) is considered the maximum consistent with good clarification. Complete analyses are made of the water supplied to the metropolis by the different companies. Some of the determinations, as for instance color, and the amount of permanganate to oxidize the organic matter, are made daily, other chemical determinations are made weekly. The monthly determinations made by Dr. Percy F. Frankland, of the bacteria in the waters of the different companies have been suspended since December, 1888. The average reduction of the number of micro-organisms present in the waters of the Thames and Lee, was in 1887, 97.6 per cent. in the case of the Thames and 93.9 in the case of the Lee. "If" says the report on the metropolitan supply for December, 1888, "these figures could be accepted as at all representing the degree of security given to consumers of the waters of those rivers by preliminary filtration it is evident that the views on this subject acquired by a consideration merely of the results of comparative chemical analysis of filtered and unfiltered waters would have to be considerably modified and the character of the water supply would be correspondingly raised in public estimation. Further, if the results obtained from month to month could be relied on as an index to the effect of filtration in eliminating objectionable matters from the water, the bacteriological method would seem to afford a delicate and easily applied test of the working efficiency of the filter."

The average numbers of bacteria in the water of the Thames is generally less than in the Spree at Berlin; thus during the year ending December, 1887 the highest number in November was 81,000, and the lowest in June was 2,200, the average for the year being 21,492.

The only filtering plant in this country, that I know of, which at all compares with the plants in Europe is that at Poughkeepsie where the Hudson River water is converted into good clear water, though not absolutely free from color. Mr. Fowler the Superintendent of the works writes me with regard to the details of the filtration, "Our usual rate of filtration is about six inches per hour, vertically, and this we regard as the maximum of efficiency, although we can sometimes do good work, so far as clarifying is concerned, at double that rate, and at other times are unable to do good work at one half that rate, although the latter condition is exceptional. Very much depends upon the condition of the water in the river. The depth of water on the sand varies from one to three or four feet and the difference of level between the surface of the water on the beds and that in the intermediate basins is usually two to four or five feet."

The rapid filtration of water through coarse gravel is not unfrequently carried out at water works to remove the larger particles floating in the water. When a filter of this kind is cleaned it is surprising to see the amount of fine dirt of all kinds that has been intercepted by the coarse material. Filters of this character do not pretend to purify the water in the sense of removing bacteria or in oxidizing the organic matter, but they are useful just to the extent to which they clarify the water and thereby improve its appearance.

The American system of filtering large quantities of water may be

said to be the mechanical filters working under pressure. These filters are composed of four or five feet of moderately fine sand (some have also a mixture of coke) enclosed generally in boiler-iron cases. They work with tremendous rapidity sometimes over a hundred vertical feet an hour, but forty feet is said by some to be the highest rate consistent with good filtration. In this system alum is generally added to the water as a coagulent. Its effect in very small amount is quite remarkable—say a grain to a gallon or even less—in retaining the solid matters of the water in the sand of the filter. The alum is decomposed by the carbonates in the water and hydrate of alumina is precipitated. This is a gelatinous and slimy substance and immediately surrounds the algæ, clay and anything else that may be suspended in the water, and the sand retains this coagulated mass. Alumina has also the effect of taking the color out of water, so that clear, colorless water may be obtained by this process from swampy waters full of growing algæ, with almost incredible rapidity.

These filters are in very general use in paper mills and other industrial works where a clear colorless water is needed, and where a colored turbid river water is the only natural supply available. They have also been introduced into some cities of considerable size as, for instance, Long Branch, Chattanooga and Atlanta and they are said to give water that is satisfactory to those who use it. The objection to the system is the use of alum. If all the alum used were decomposed in the few seconds that it takes the water to pass through the filter, so that no undecomposed alum passed into the filtered water, there might be no objection to its use, but this is not always the case. The amount of alum used is ordinarily small and it is claimed that if it even all went into the filtered water it would not injure it for drinking. This may be so but the prejudice that exists against drinking water which has been treated with "chemicals" is so strong that it is not likely that any system using a coagulent in a soluble form will find general acceptance. Under some conditions when the water has high color with much suspended matter the alum has to be increased largely to give good results. I have known as high as seventeen grains to the gallon to be used with a very bad swampy water.

In this connection should be mentioned the spongy iron filter of Bischof which gives most excellent results both in taking out suspended matters from the water, including the bacteria, and also decreases the hardness of the water. This filter has been used on the small scale in houses, and also on the large scale in Antwerp to decolorize and otherwise purify the water of that city. The filter is composed of finely divided metallic iron made by reducing iron ore by means of carbon at a temperature below fusion. Its action was not understood for a long time, and the mystery that surrounded it was an additional recommendation for it. The rationale of its working seems to be this, namely, that the iron being in a very finely divided state is dissolved to a slight extent by the combined action of the oxygen and carbonic acid in the water, and the ferrous carbonate thus produced is further oxidized, forming hydrate of iron, and then this acts as a coagulent just as the alumina hydrate does. The system was said to be too expensive on a large scale, and it has now been replaced at Antwerp by the Anderson process in which the dark water is

made to pass through a long revolving iron cylinder in which there is a large quantity of fragments of cast iron. These fragments of iron in their friction one on the other are abraded, minute particles are broken off which are dissolved in the way above described. The water coming from the revolving cylinder is exposed to the air, the iron oxidizes and precipitates, combines with the coloring matter in the water, encloses the solid particles, and is then filtered out through sand. The process is said to work satisfactorily and give clear colorless water. There is no objection to this use of iron as a coagulent provided that it is all oxidized and precipitated, and none is carried in solution into the filtered water; but this takes time.

Both alum and iron salts have a tendency to sterilize water. Their action may be both direct by killing the bacteria, and indirect by removing them with the precipitated alumina or iron hydrate. If a drop of a solution of alum, or of iron chloride be added to a gallon of turbid water, it will become perfectly clear in the course of a few hours, the alumina, or iron hydrate, which is formed in the water, settling to the bottom and carrying all the suspended matters with them. It has been proposed to clarify Missssippi water by adding a very small quantity of an iron solution to the water in the settling basins.

I have laid some weight on the desirability of following nature's processes in the purification of impure waters. Neither the American system with its mighty rush of waters or the European system with its calm, steady and deliberate flow finds any analogy in nature. In the rapid-working mechanical filters a coagulent is used to grasp and hold the suspended matter; in the continuously working filter beds the bacteria are put to a novel use in retaining the solid matter on the sticky surface of the sand.

Nature uses these methods also, she removes color by means of clay in the soil and intercepts mechanically in the bacteria-laden soil all the solid matter in the water, but she goes further than this and, giving the bacteria full play, breaks up the organic compounds and leaves no trace of their existence behind. To do this time is needed. "The bacteria of nitrification," as Dr. Smart has well said, in referring to the systems of rapid filtration, "cannot be harnessed to the work of artificial filtration."

The rate at which nature works may be expressed in the amount of rain-fall. If we take the rain-fall at fifty inches and assume that even half of this sinks into the ground (a very high estimate) we have twenty-five inches yearly on a square foot of surface. The amount of water which goes through the Berlin filters, at a rate of four inches an hour, is more than 1,250 times this amount. If we wish to imitate the process by which nature makes its springs we must pour the water from river or lake which we wish to filter intermittingly on the surface of ground which is favorable for this purpose The favorable conditions are these, the ground must be sufficiently porous to allow the ready flow of water through it, and it must have such relations to the strata below as will enable us to collect the water at some lower level. It would not profit us much to pour the water on to a gravel bed if we could not find it again after it had been filtered. If the natural conditions for this purpose are not favorable drains would have to be put in at suitable depths to collect the filtered

water. Water purified in this way would in no wise differ from natural spring water, provided that the amount of water applied did not exceed the capacity of the filtering area.

The question of the maintenance of the purity of the water supplies of large cities, which are dependent upon surface waters, is daily becoming more urgent in this country as the population becomes more dense on the collecting areas, and the protection of streams against pollution becomes more and more difficult. The radical remedy in such cases is to take water from another and, usually, more distant region, which, it is probable, will never become thickly settled. But in filtration, both intermittent and continuous, when intelligently conducted, we have a substitute which can give as clear, colorless, and, we have good reason also to suppose, safe drinking water.

DISCUSSION.

PRESIDENT FITZGERALD:—I suppose it is hardly necessary for me to add a word to what has been said. I only give expression to the views of every member when I say, we are extremely fortunate as a society in having heard this paper at this time, as it represents the most advanced views on filtration in this country and a very excellent summary of what has taken place on the other side of the water. We certainly owe a great deal to Prof. Drown for having taken the pains to give us the benefit of his experience. The subject is now before you for discussion, and I suppose the Professor will be glad to answer any questions.

I will say that if there are any gentlemen present who are not members of the Society, we shall be glad to hear from them. Dr. Abbott of the State Board of Health is here. I hope he will enter into the discussion.

DR. S. W. ABBOTT: Prof. Drown has gone over the subject so thoroughly I do not think anything could be added to it. The question, *popularly* speaking, of the impurity of water, differs very much from that in which a scientific man would view it, for the people look on impure water as necessarily harmful. The Melrose, Springfield, Brockton and other waters may be offensive to smell and taste, and yet it has not been determined that any disease has followed such tastes and odors.

This whole subject, of course, has a very important bearing upon the medical side of the question; that is, the relation of filtration of water to the prevention of disease, and it undoubtedly has a direct effect in that way. We believe now that the effect is the removal of the bacteria. The more we find out in regard to them, the more we discover they are associated with infectious diseases, namely: those diseases which are preventable, or communicable.

The more we have of such intelligent papers as we have heard read to-night, the more superstitious and fallacious notions will be corrected and the people will be put in possession of the means of prevention of the causes of the pollution of water.

PROF. WILLIAM WATSON: It was my fortune last summer to see a number of experiments with filters, and although I had very little time, it being just when I was going away, yet the experiments which were performed by a person who was using charcoal, seemed to be very extraordinary. I had just come from Pasteur's laboratory where I saw a number of filters that have been described, and was rather curious to know how they worked. I went into the laboratory of a very celebrated manufacturer of filters. Mr. Maignen, who assured me that his filters were capable of not only purifying ordinary water, but of actually separating from it metallic salts in solution. For instance, he said, "I now take a solution of sulphate of iron and will show you (testing a portion of it with yellow cyanide of potassium, and showing the intense Prussian blue precipitate), that in passing it through this charcoal filter, the sulphate of iron has been entirely removed." And he made this experiment, passing the solution of sulphate of iron through the filter, and testing the effluent with yellow cyanide of potassium, and to my great surprise, it showed no trace of the salt. He made a similar experiment with acetate of lead in solution, which gave a copious black precipitate with sulphydrate of ammonia, but no precipitate after solution, and he did it with a number and stated that his process was capable of very great extension. I would like to ask Prof. Drown whether, in his opinion, any such separation can take place with simply a metallic salt in solution?

PROF. DROWN.—A solution of sulphate of iron or copperas added in small amount to water oxidizes almost immediately, and a rusty precipitate settles after a time. If the solution is added to the water just before filtration this oxide of iron will be filtered out, whether the filtering material is composed of charcoal, sand or other material. I do not know what is the character of the filter Prof. Watson refers to, but it is not necessary to suppose from his description that the material of the filter possesses any oxidizing action.

PRESIDENT FITZGERALD.—The subject of filtration is one that some of our large cities have been devoting attention to, and I think they will give more and more attention to it year by year. It strikes me, from studies that I have made of the subject for the last eight or ten years, that it is destined to be one of the most important things in connection with the development of water works in this country. I think that perhaps we have been as engineers rather too much hurried in furnishing water to cities and towns without having had the time, which will come as the country gets older, to look into the question of quality. It has only been within the last few years that engineers on waterworks have devoted very much thought in this country to the subject of quality. This paper by Prof. Drown is almost the only paper we have heard recently on the subject. Fourteen or fifteen years ago Mr. Kirkwood made a trip abroad in the interests of the city of St. Louis and published a very valuable volume, on the filtration of water in Europe, but from that time to this there has not been much done. These experiments at Lawrence, however, from what I have seen of them, are going to throw a flood of light on the subject. About a year ago I made a series of experiments for the city of Boston with a view of removing the micro-

organisms, except the bacteria, without going into an expensive plant, and I found, in passing water through one-half inch of sand with very small heads that about eighty per cent of the organisms could be removed. Of course, it would have no effect on such small organisms as the bacteria. This, however, is hardly filtration. It seems to me that our large cities are destined to take up the subject in a more serious way before long. I do not know why the citizens of a city may not well demand that water shall be free from all kinds of life. Although this life may not be necessarily deleterious, yet it is certainly disagreeable to say the least for instance to feel that you cannot go to the faucet in the dark to draw water without the liability of getting almost any kind of life in the water. I know that engineers generally have rather laughed at the esthetical view of the question, but I think a more careful consideration of the subject will be given in the future. Certainly if water can be freed from deleterious matter, free ammonia, and matter in a state of decay before delivery to a city, changed chemically, all ammonia carried down to the nitrates, why, of coure, that is a welcome door of relief. Can Prof. Drown give us the quantities dealt with at Berlin—the daily consumption?

PROF. DROWN.—I cannot give them accurately from memory. The publications of Piefke contain much that is interesting on the subject of the Berlin water supply. His works on filtration are:

Mittheilungen ueber natuerliche und kuenstliche Sandfiltration. pp. 75, Berlin, 1881.

Die Boden Filtration pp. 51, Berlin, 1883.

Die Principien der Reinwasser Gewinnung vermittelest Filtration. pp. 50, Berlin, 1887.

Aphorismen ueber Wasserversorgung von higienisch—technischen Standpunkte aus bearbeitet—Zeitschrift fuer Hygiene. 1889, Vol. 7, p. 115.

With C. Frankel—Ueber die Wirksamkeit der Sandfiltration zur Befreiung des Trinkwassers von etwaigen Infectionskeimen Zeitschrift fuer Hygiene, 1890. I.

MR. SIDNEY SMITH.—In going through Old Mexico, from Vera Cruz to the City of Mexico, and thence to Manzanillo, I noticed almost everywhere in the better class of houses the filters made of volcanic stone. They are of various shapes, but usually in the form of a thick jar perched on a frame five or six feet high, and kept moist with water always. Underneath them, generally near the floor, is a porous jar of earthen ware which receives, drop by drop, the water from the filter above. Now, I do not know, in fact never questioned, what the process was, how the water was improved, as our friend from New Mexico says. There was less water used in Mexico than in some other places, the custom being to mix the claret wine with water, half and half.

THE PRESIDENT.—Does not evaporation take place from the lower jar?

MR. SMITH.—Yes, sir; I have seen that tested. The evaporation lowers the temperature of the water from four to eight degrees below that of the surrounding atmosphere, and the water from those jars is very palatable to drink.

PRES. FITZGERALD.—I think, Mr. Watson, the French have been very active in developing different kinds of filters for different purposes. For instance, the soldiers carry little portable filters whenever sent to Africa, so that whenever they stoop down to drink out of a pool, they put that into their mouths. Is that not one of the Maignen devices? They certainly recognize the value there of filtration for ordinary uses.

PROF. WATSON.—The English soldiers are also provided with a sort of portable charcoal filter which they carry round on all their campaigns.

PRES. FITZGERALD.—I think it is a French filter.

THE CHICAGO RAILWAY PROBLEM, ESPECIALLY IN RELATION TO TERMINALS, RAPID TRANSIT AND THE AVOIDING OF ACCIDENTS AT STREET CROSSINGS.

II.

BY MAX E. SCHMIDT, MEMBER WESTERN SOCIETY OF ENGINEERS.

[Read June 4, 1890.]

I have hardly resided long enough in this city to claim the privilege of your attention in this important discussion. It often occurs however that local prejudices complicate a problem and prevent those most familiar with the same from forming an unbiassed opinion, which is essential for its solution.

In this connection, I feel justified in saying that no person can live here six months and remain in ignorance, 1st.: of the encroachments of the railways upon the city's territory; 2nd: of the defects of the terminal facilities, and 3rd: of the inadequate arrangements for rapid transit, provided for the population of this great city.

One glance at the city map reveals the seriousness of the situation, and the urgency of the demand for a speedy remedy. Indeed, it seems impossible to conceive that Chicago can keep up that phenomenal growth in wealth, area and population, which has distinguished it in the past without a radical change in the railway arrangements, as they exist to-day.

I believe it has once been said of this city, that the river, the bridges and the railroads would in time become so unbearable, that the people would rise under a common impulse, to fill up the river, spike down the bridges, and transfer the railways to the place occupied by the river.

While the first part of this prediction has evidently been realized already, the remedy proposed is, of course, visionary. Each problem is receiving separate and careful attention and, while the drainage act will

deal with the river, and tunnels are taking the place of bridges, the railway problem, which has been before you at several meetings, and of which lengthy discussions have appeared in the public press, is still imperfect and practically without a solution, even on paper.

In reference to this problem, while the opinions, which we have heard, have generally been expressed against a radical change, the suggestion has also been made to propose a remedy that would be sweeping and complete, and then try to approach the same as close as possible.

It is in line with this suggestion that I shall lay before you not a plan, nor a scheme, but simply an idea, or a suggestion of what a plan might be if the problem was to be eradicated forever. I refer to nothing less than to the possibility of uniting all the railways, entering Chicago, at a point five or six miles west from here, and provide one wide entrance, for the construction of an embankment, on which all the railways may come in, side by side, on parallel tracks, and discharge in one commodious Union Depot.

Considering the geographical position of Chicago, whose entire east side fronts toward the lake, from which direction railways cannot approach, such an arrangement would certainly be most desirable, provided it could be accomplished.

The map will illustrate the plan.

The deflection of the tracks toward the west begins, in the southern division, at Calumet and, in the northern division, at Evanston. All roads are one by one gathered up, in such a manner that the growing line follows more or less closely the present Belt Line Railway. That is to say, each railway, as it approaches the Belt Line, in place of crossing the same, makes a turn and occupies the outside of the tracks already in place. When the stem is reached, all tracks turn back east to occupy the avenue that has been provided for their common entrance into the city.

This would bring into existence one broad and many tracked belt railway on which the Pittsburgh and Fort Wayne in the southern division, and the North Western in the northern division, would occupy the inside tracks. Every railway would remain independent, but have direct track communications with its neighbors. There would be practically no grade crossings within the city limits, no delays, no gates and no accidents. All freight, not destined for the city proper, would be shifted at the Chicago Union Transfer Yards, while for the handling of Chicago freight track space and sheds could be provided on wings of the elevated embankment, near the terminus.

The route of the central stem, on the map, is simply chosen as an example. It follows the right-of-way of the Burlington, under the belief that it would be impossible to go by that route, which is wide already and admits of much widening on both sides. In practice the central stem would necessarily follow a line, where the right-of-way could be obtained at the lowest price, and where the location would disturb existing conditions least.

The embankment should be so constructed that the railway problem would thereby be disposed of forever. For that reason, the first three or

four miles, west of the terminus, should be composed of a solid earth embankment, raised to an elevation of at least fifteen feet above street grade, and held in place by two strong masonry retaining walls. All streets, running parallel with the embankment, as far as covered by the same, should be closed, while communication, between streets running transvesrely, should be kept open by means of masonry archways, lighted by electricity. Beyond the three or four mile lines, or wherever property ceases to be very valuable, retaining walls could be dispensed with and the embankment constructed with ordinary side slopes. At the same time, its elevation could be decreased to nine feet above the street grade, and the archways, extending tsansversely through the same, could be depressed sufficiently to make up the difference. This elevation should be retained until the embankment leaves the city limits.

The magnitude and absolutness of the change outlined, affecting, as it would, all existing conditions, not only where the new line would be traced, but in every quarter of the city, where old tracks would be vacated precludes the possibility of rendering an estimate of its cost, at this stage. Moreover, to render an estimate would not be in conformity with the statement, that this is a suggestion only, and not a plan upon which estimates might be based. But a brief analysis of the proposition may be given, as it will reveal at once its chances, if any, of ever becoming realized, in whole or in part, and in this shape, or any modification thereof.

Referring first to the items of grading, bridging and masonry, it is, of course, much cheaper to place, say seventy tracks on one embankment, than to place each one on a separate one. In this particular case, Mr. Robinson estimates the cost of four track viaducts at $1,106,000 for metal, and at $706,000 for masonry viaducts, per mile respectively. At this rate one mile of seventy tracks, placed on viaducts of four traccapacity each, would cost $19,355,000 and $12,355,000 respectively. To place the same number of seventy tracks side by side on one common embankment, one thousand feet wide, and of the class I have described, would cost only about $3,300,000 per mile, or slightly more than one fourth of the smallest of Mr. Robinson's estimates. In this sum earth is estimated at fifty cents and retaining wall masonry at six dollars per cubic yard, and no allowance has been made for debris from houses to be removed, which would necessarily assist in reducing the cube of the fill.

Referring to the suggestion of raising or depressing separately all the tracks within the populous parts of the city, little has been said how this is to be done, without obstructing the enormous daily traffic of each road thus treated. How far this could be overcome by the construction of temporary tracks, or by shifting the railways amongst themselves, during construction, or by mechanical means, at an outlay of money, remains to be seen, but to disturb the surface level of *any* railway, especially to the extent as proposed here, and when that railway is doing the business of a *Chicago* railway, is a serious problem under the *best* of circumstances. Hence a plan that would be free from this objection, and permit the railways the undisputed use of their right-of-way, during the process of raising or depressing the tracks, would seem very desirable, and it may be said that under the proposition of uniting the tracks, as outlined in this paper,

the existing railway traffic would not be molested; for the railways would simply not occupy the new tracks until after they are completed. Only in case of one railway consenting to give up its right-of-way for the purpose of enlarging the same, to conform to the requirements of this proposition, a temporary entrance into the city, by one of the other routes, would be required for that railway. But the vacated tracks would be of great assistance during construction.

Violent changes of existing conditions are, however, as a rule regarded as unsafe and impracticable and, no doubt, the same rule for many reasons, local and general, would apply strongly here. The chief argument against the change, in this case, would be the immense value of the property, which the railways have acquired within the city limits, and the pretended uselessness of this property for any but railway purposes; also, because of the many industries, which are now dependent for track room in the very heart of the city, and which would be cut off from their base of supplies if the railways were withdrawn.

To meet the first of these objections properly, would require the laborious task of ascertaining the value of the entire present railway property, within the city limits, and compare it with that which the transferred tracks would jointly represent, after removal. The present value is placed all the way from sixty to two hundred million dollars, distributed over twenty-nine different railway lines, which enter Chicago on sixteen distinct right-of-ways, covering many square miles of the most valuable city property. All this property would become vacant were the railways to be transferred, but its character would seem to indicate at once its usefulness for purposes of suburban rapid transit, by cable or elevated roads, and greatly facilitate the acquirement of the right-of-way for these purposes. A large part of the vacated property would be disposed of in this manner, while the rest would become available for streets and building lots.

As regards the industries no thoughtful person will dispute the superior part which they play in the Chicago railway problem. Each railway penetrates with a net work of yard and spur tracks into the various industrial quarters of the city and depends upon them for traffic, as the tree does for nourishment upon its roots. The industries look therefore upon their present locations as fixtures and, with the power, incident to the large investments represented, are solid against any attempts to disturb them and interfere with their present track facilities. This point was illustrated, I am informed, when some time ago the desire of a railway line to elevate its tracks at a complicated crossing in this city, was frustrated through the pressure brought to bear against the measure by the industries near by. What their resistance will be to any plan, which has in view the raising of the tracks in a body or their removal to another part of the city may therefore easily be surmised.

The problem is thus brought to the very door of the industries, with the absolute certainty that it must grow vastly more complicated in the future, if the preponderance of the industries is conceded and their disturbance considered altogether impracticable. If such a measure as was outlined in this paper, would be adopted the natural course of events

would lead the industries to follow the railways to where tracks could be provided for them and, the difference between central and suburban property would go a long way toward paying for the expense of their removal. For the city, their disappearance would not necessarily be a loss, if for no other reason, but that their departure would result in the removal of at least one of the causes that combine to make this city one of the smokiest and dirtiest in the country.

In conclusion it should be stated that the idea suggested here admits clearly of modifications. Thus, in place of conducting all the railways into one artery, for their joint entrance into the city, it may be that existing interests would be served better by dividing them into groups, one southern, one western, and one northern group, and carry each one into the city on separate embankments, for which routes might be selected that would touch most of the existing industries and elevators, providing them with tracks from short inclines, leading down from the embankments. Or, it might be suggested to carry the central stem out to a point three or four miles beyond the city limits, and let the union of tracks take place there, which would make the line straighter, grading less expensive and remove more crossings.

What the people want is a remedy that will, if possible, free them from this railway problem forever. If a *radical* change, which *alone* would accomplish this end, is impracticable, *then* we must look for a compromise, that will be perfect and adequate, and, at the same time, satisfactory to the interests at stake. No better plan to bring about such a compromise, can be suggested than to submit all plans and propositions to a board of experts, convened upon the request of parties interested, and on which these parties themselves are represented. With such a board, properly authorized to collect what we need most, *data* and *information*, we may rest assured that the problem will be sifted to the bottom and a final plan prepared that stands a good chance of being adopted.

I understand that there is a hope of having such a board appointed at an early day.

ASSOCIATION OF ENGINEERING SOCIETIES.

PROCEEDINGS.

ENGINEERS' CLUB OF KANSAS CITY.

JUNE 20, 1890.—An excursion was taken to Merriam Park by a special train, over the K. C., F. S. & M. Railroad, leaving at 12 o'clock, eighteen members and twenty visitors being present. After the inspection of some bridge abutment masonry on the line of the road near Rosedale, and partaking of an out door lunch at the park, Mr. Gillham read a paper on "High Speeds and Defective Details in Marine Engines," referring especially to the accident to the steamer "City of Paris."

Contrary to the originally accepted opinion, Mr. Gillham thought the immediate cause of the accident was due to the insufficient strength in the connection between the piston and the piston rod, considering the high speed and immense weight of parts; that with greater coning to the piston, the use of governors acting simultaneously on each of the three cylinders, by the constant presence of the engineer at the throttle, by greater efficiency in the training and discipline of the crew and by being content with a more moderate speed of the vessel, the accident, if not prevented, wonld not have been of so serious nature.

After a discussion by Messrs. Gunn, Goldmark, Talmage, Mason, Breithaupt and Knight, the President accepted with thanks the Club's request that he should retain his office until the next regular election.

The party returned at about 5 o'clock after a most enjoyable excursion.

KENNETH ALLEN, Secretary.

CIVIL ENGINEERS' CLUB OF CLEVELAND.

JULY 8, 1889—The regular meeting was opened at 8:15 p. m. President Searles in the chair. In the absence of the secretary, Mr. C. O. Palmer was appointed Secretary, pro tem. Present, eighteen members and three visitors. The minutes of the June meeting were read, and, after correction, approved. The Secretary, having arrived, took his seat, and relieved Mr. Palmer.

The name of Mr. James Morris Wright was presented for ballot, for active membership. Mr. Mordecai and Mr. Palmer were appointed tellers, and on their report Mr. Wright was declared elected.

The Executive Board reported the purchase of a Secretary's desk, which was ong needed, and it is now in the Club room.

Mr. Gobeille reported for the Committee on Picnic, giving some particulars which will be more fully stated in a circular.

Mr. Mordecai then reported for the Committee on Affilation that he had heard from Mr. Holloway, who had attended the meeting appointed in New York for conference, and that the attendance was very small, and nothing was accomplished at that time.

The President read a letter from Mr. Kirchhoff, Jr., Secretary of the American Reception Committee, stating that owing to a change in the program, the party of Foreign Iron Masters and Engineers would not visit Cleveland; however, some individual members may be able to do so.

Mr. Gobeille mentioned the receipt of a letter from Gen. Wilson, Superintendent of West Point, N. Y., expressing the writer's continued interest in the Club.

The Amendments to the Constitution of the Association of Engineering Societies,

proposed by the Board of Managers and published in the December number of the Journal, were presented for consideration. On motion of Mr. Barber, seconded by Mr. Gobeille, the first and second amendments were separately discussed, and finally adopted.

The paper of the evening on "Methods of Wall Decoration" was read by Mr. C. O. Arey. After noting the objections to oil colors and kalsomining process, he narrated his experience with other methods. The encaustic process as practiced by the ancient Greeks was found too expensive. The fresco practiced by the early Renaissance was found satisfactory with the exception that the work was liable to be injured or broken, after completion, by the finishing carpenters. He then tried many experiments to find a method similar to this fresco, which could be applied on a dry wall; this was accomplished by a chemical union of alum and lime, providing only mineral colors were used. This method allows one to apply on the wall a permanent finish unaffected by water at a very moderate expense. The paper was then discussed by Messrs. Barber, Herman, Richardson, Porter and others.

(Adjourned.)

After adjournment many members of the Club visited the fallen electric-light mast which was wrecked by the storm a few hours previous.

A. H. PORTER, Secretary.

ENGINEERS' CLUB OF ST. LOUIS.

331ST MEETING, JUNE 18, 1890. The Club met at 8:15 p. m., in the rooms of the Elks' Club, Vice-President Burnet in the chair; seventeen members and three visitors present. The minutes of the 330th meeting were read and approved. The Executive Committee reported the doings of its 94th meeting.

An application for membership was announced from Richard Klemm, Park Commissioner, city of St. Louis, endorsed by M. L. Holman and Geo. Burnet.

The Secretary then read a communication from the Chairman of the Board of Managers of the Association of Engineering Societies, calling attention to certain amendments to the Articles of Association, which had been adopted by the board, and were now being submitted to the societies for ratification. These amendments may be fonnd on page 589 of the Journal for December, 1889. On motion of Mr. Seddon, it was ordered that a special committee of three be appointed to consider this matter and report at the next meeting. Messrs. J. A. Seddon, B. L. Crosby and W. H. Bryan were appointed such committee.

The Secretary then read Prof. Chas C. Brown's paper on "River Pollution in the United States." The author divided the treatment of his subject into three heads: First, streams used for water supply only; second, streams used for draining purposes only; third, streams used for both water supply and drainage. The paper was confined principally to the consideration of the latter class, it being the most important. The author gave abstracts of the work done in different states heretofore, in the direction of investigating the pollution of streams, accompanying his remarks by tables, showing the results of chemical analyses of a large number of different waters. The author stated that he would be glad to receive further data and asked for criticism and discussion of the subject. After brief discussion by Messrs. Beahan, Seddon and Holman the meeting adjourned.

WM. H. BRYAN, Secretary.

MONTANA SOCIETY OF CIVIL ENGINEERS.

APRIL, 19, 1890.—The regular monthly meeting was held at the office of the Chief Engineer, Montana Central Railway, President E. H. Beckler in the chair. There were twelve members and two visitors present.

The minutes of the last regular meeting were read and approved,

Under the head of balloting for members Messrs. Danse and Pearis were appointed by the chair as tellers.

Mr. Samuel D. Bridge was declared elected to membership.

Under reports of committees Mr. Haven, chairman of the Committee on Affiliation with the American Society of Civil Engineers, requested that the Secretary read printed plans A, B, C, D, and E, furnished in pamphlet form by Mr. Wm. P. Shinn, Chairman American Society Civil Engineers' Committee. After reading plans A and B, Mr. Herron moved that the plans be referred back to the Committee on Affiliation, with the request that after a consideration of the various plans the committee advise in favor of one or other of the same. Mr. Haven stated that the time was too short to allow any delay, as the meeting at which the matter was to be decided was to be held the first week in June. Mr. Herron withdrew his motion, and the Secretary proceeded to read plans C, D, and E. The various plans were then discussed by members.

Mr. Keerl expressed himself in favor of affiliation. Mr. Kelley moved the matter be referred back to the committee with instruction to pay particular attention to plans C and D. Seconded. Mr. Danse moved as an amendment that the committee be authorized to act finally for the Society without limit to any plan. Seconded. After discussion, and by consent of second, Mr. Danse withdrew his amendment. Mr. Foss moved as an amendment that the committee be instructed to report at a special meeting two weeks from to-night. Amendment seconded and accepted. Motion as amended carried.

It was requested by Mr. Haven that the Secretary state the object in notifying members of the time of special meeting.

Mr. Sizer reported for the committee on report to Hon. T. H. Carter, M. C., and submitted a letter from Mr. Carter's secretary acknowledging receipt of his communication. Mr. Sizer stated that he would furnish the Secretary a copy of the communication mentioned in Mr. Carter's letter.

Under the head of unfinished business, the amendment to the By-laws, Sec. 3, Art. IV., was, on a count of votes, declared carried, there being fifteen votes in the affirmative and four in the negative.

The President appointed as a committee on Topics, Mr. Sizer, Mr. Danse, and Mr. Foss.

Mr. Herron moved that the vote on election of members, and on the amendment to By-laws, as announced in these minutes, be stricken out as unconstitutional under Sec. 4, of Art. VI. Seconded and carried.

Mr. Herron moved that the Secretary be instructed to send out new letter ballots, both for candidates for election and also for the amendment to the By-laws, and that the members be notified of the reason for a reballoting. Seconded and carried.

Mr. Foss called for the reading of the list of delinquent members. After the reading, Mr. Keerl moved delinquent members to the extent of six months be notified finally, and warned that further delinquencies on their part would subject them to the penalty of being dropped from membership in the Society, and that their attention be called to Sec. 7 of Art. V., of the By-laws. Seconded and carried.

Under the head of unfinished business Mr. Haven gave notice that at the next meeting he would introduce an amendment to the constitution, authorizing the appointment of a Committee on Membership.

Adjourned. CHARLES G. GRIFFITH, Secretary.

MAY 3, 1890.—A special meeting was held at the office of President E. H. Beckler, Second Vice-President John Herron in the chair, with five members present.

Mr. Keerl was elected secretary pro tem. The chair stated the call for the meeting and Mr. Haven submitted the report of the Committee on Affiliation with the American Society of Civil Engineers, which was read, discussed and adopted.

Adjourned. J. S. KEERL, Sec'y Pro Tem.

MAY 17, 1890.—The regular monthly meeting was held at the office of President E. H. Beckler, at 9 p. m., Second Vice-President John Herron in the chair, with seven members present.

Owing to the absence of the Secretary the reading of the minutes was dispensed with. Mr. Haven offered a resolution, pursuant to the notice given at the previous regular meeting as follows: Amendment to Sec. 3, Art. IV. of By-laws. Strike out the whole section and substitute the following:

"All applications for membership must be presented at a regular meeting of the Society and be read, and then referred to the Board of Trustees, who shall investigate the qualifications of the applicant and report thereon to the Society at the next regular meeting, at which time they shall be again read, together with the report of the Trustees, and if by a vote of the meeting the applications are received, they shall be submitted to a letter ballot of the whole Society, but the ballots for each candidate must be on a separate piece of paper, negative ballots will reject."

Explaining that the blank in the final sentence was to be filled out in such manner as would be dictated by the result of the vote on the amendment pending, and the sense of the meeting. Seconded by Mr. Foss.

The chair ruled discussion was out of order before next regular meeting, at which time it should be considered.

Adjourned to 31 inst. L. O. DANSE, Sec'y Pro Tem.

MAY 31, 1890.—An adjourned meeting was held at 8:30 p. m., at the office of Mr. E. H. Beckler, Chief Engineer Montana Central Railway. In the absence of the President, Col. W. W. de Lacy occupied the chair. There were present twelve members.

The minutes of the three previous meetings were read and approved.

Samuel D. Bridge was declared elected a member of the Society.

The Secretary was directed to send to Mr. Wm. P. Shinn, Chairman A. S. of C. E. a copy of the report made by the Committee on Affiliation with the A. S. of C. E.

The vote upon the following amendment to the By-laws was canvassed and the amendment declared adopted: That Sec. III. of Art. IV. be amended by striking out in said section after the word "ballot," in the fourth line, the words "An affirmative vote of three-fourths of the votes cast shall be necessary for election," and inserting in lieu thereof the words "Five negative votes shall debar the candidate from admission."

The Secretary called attention to his resignation tendered at the regular meeting of the 17th inst. He stated that the step became necessary, due to his frequent absence from Helena, preventing him from giving proper attention to the work. Mr. Danse moved the resignation be accepted. Carried. Mr. Kelly moved the thanks of the Society be tendered the retiring Secretary for his services. Carried unanimously.

Mr. Keerl moved that a committee of three be appointed to select a suitable member as a candidate for Secretary, and that a temporary Secretary be appointed to fill the office until such selection is made. Carried.

Mr. Griffith nominated Mr. Kelly as temporary secretary. Mr. Kelly nominated Mr. Keerl. After an endeavor made by both gentlemen to decline, the chair appointed Mr. Keerl as temporary secretary. The chair appointed as the committee to select a candidate, Messrs. Haven, Hovey, and Danse. A motion prevailed that by reason of being a member of such committee should be no bar to his selection as a candidate for Secretary.

Mr. Keerl moved that the Secretary be instructed to secure for the Society's Library all the back volumes of the Proceedings of the American Institute of Mining Engineers, and that he communicate relative thereto at his earliest convenience, with the Secretary of said Institute. Carried.

Mr. Keerl moved that the Secretary be directed to communicate with the Secretary of the American Society of Civil Engineers relative to securing for the Society's Library, all the back volumes of the proceedings of said Society—except those now owned by the Montana Society. Carried.

By motion of Mr. Haven, the proposed amendment to Section III. Article IV. offered at the monthly meeting of the 17th inst., was read. Mr. Kelly offered as a substitute for the amendment that the President appoint a committee of three to revise the Constitution and By-laws. Carried.

The resignation of Mr. G. E. Ingersoll was read. The Secretary moved the resignation be accepted on payment of dues, if any, as required by the By-laws. Carried.

Adjourned. CHARLES G. GRIFFITH, Secretary.

WESTERN SOCIETY OF ENGINEERS.

JUNE 4TH, 1890.—The 270th regular meeting of the Society was held at its rooms Wednesday evening, June 4, 1890., at 8 o'clock p. m., President L. E. Cooley in the chair and some fifty members present.

The minutes of the preceding meeting were passed and the Secretary gave a report of the meeting of the Board of Directors. The following members were elected: Messrs. Frank F. Heck, John Henry Spengler, Samuel V. Ryland, James J. Reynolds, Henry F. Baldwin, Emil Gerber, Fred. T. Rolph, Charles J. Peters, Edward Shelah, H. S. Houck.

The following applications were filed: Rudolphus B. Bourland, C. F. Theodor Kandeler, Edward L. Abbott, Charles Levings. Mr. H. B. Alexander, of Geneva, Ill., renewed his membership.

The following report of the special committee appointed to consider the communication from the American Society of Civil Engineers, on the subject of Affiliation of Engineering Societies, was then presented to the Society.

CHICAGO, May 29, 1890.

W. P. SHINN, ESQ.,
Chairman Com. on Revision of Constitution and By-laws, American Society of Civil Engineers.

DEAR SIR:

The Committee appointed by the Western Society of Engineers, to confer with your Committee with a view to determining whether a satisfactory basis can be established for an affiliation with the American Society of Civil Engineers, begs to submit the following views, in accordance with your request, as contained in your circular of March 26, 1890.

Engineers are generally agreed that it is most desirable that there should be a close union and co-operation between all the members of the profession in this country, as well as of the individual engineering societies. In no other way can concert of action be so well obtained to elevate the acquirements and position of Engineers. The main difficulty in the way hitherto, has been the lack of some adequate plan of bringing about that union which gives strength.

In this respect the five suggestions appended to your circular seemed to us scarcely complete enough to be discussed individually, but they may be divided into two classes:

1. Affiliation plans, A, B and C.
2. Federative plan, D.

The preference of our Committee is for some form of organization which will afford the advantages both of affiliation and federation and which will build up one strong homogeneous society, open to all the members of the profession, under their appropriate grades, provided that this can be organized so as to recognize in some way all the existing local societies and their membership, and preserve the autonomy of the societies, and foster the local meetings which have been found so valuable as to lead to the increasing organization of Engineers' clubs, even where the members were already connected with the Am. Soc. of C. E.

We believe therefore that any affiliation plan must in the main provide features embodied in the accompanying "Suggestions for a General Organization of Engineers." For the American Society to accomplish this it would be necessary:

1. To continue the present members of the local societies in connection with the reorganization, under appropriate grades.
2. Local meetings and self-government of each branch so far as this casts no responsibility upon the general organization.
3. Representation of each branch in the general Board of Direction.
4. That the Board of Direction shall be representative of the several units composing the organization.

Should these features be deemed objectionable there will remain the alternative of some loose federation for the reading, discussion and printing of papers, such as that outlined in plan D, but even this will need elaboration and eventual discussion in some joint committee meeting of all the societies interested.

Respectfully submitted,

Signed, BENEZETTE WILLIAMS,
A. GOTTLIEB,
O. CHANUTE, per L. E. COOLEY,
H. B. HERR,
A. F. NAGLE.
Committee.

SUGGESTIONS FOR A GENERAL ORGANIZATION OF ENGINEERS.

A. The ultimate purposes on which Engineering Associations should be founded seem to be.

1. Social fellowship, exchange of professional experience and the fostering of brotherly relations by union in a common body of all members of the engineering profession, and those entrusted with the management of carrying out of engineering enterprises.

2. The preparation and publication of original engineering experiences and special investigations of technical interest, and of "contributions to kno wledge" on subjects recognized as importat, but for which the demand is too limited to justify cost of commercial publication, and to embrace all current literature by abstract or index in one publication.

3. To encourage and secure through individual, corporate and governmental agencies, the systematic valuation of all the "forces and materials of nature" with which problems of engineering are concerned.

4. To influence and direct public legislative opinions in matters of policy concerning those public works in which the engineer is better fitted to give advice than any other class of citizen.

A place of resort for engineers in every centre of population where they may meet each other, discuss current topics and entertain those in related fields is recognized as of prime importance.

At meetings of local bodies, technical contributions are important, but if worthy furnish little material for discussion. They are matters of individual reading and criticism and careful thought. Discussion of such contributions in public assemblage does not enlist interest or secure attendance.

Experience shows that the profession is interested in the settlement of controversial questions which present true issues, and in matters of public policy related to public works.

There are also broad questions of general concern, and a large field of common purpose, which concerns the profession as a whole; but the nature of these more general questions does not call for frequent meetings, nor are frequent meetings practicable for a national organization. The detailed formation of opinion is best accomplished through smaller bodies than such an organization.

The general organization should in no way be restrictive, but may be suggestive to the local organizations, as the initiation of action important to the profession, and the carrying out of the same must be mainly discretionary with the local bodies leaving to the central body largely the coordination of effort.

B. The following general plan therefore follows:

1. An organization of all branches of the profession in one association, the general membership to be attached to local bodies when within certain distances of such bodies, the local bodies to have other membership purely local or that have all privileges with the right to vote restricted to the local organization.

2. Each local body shall be organized under the same constitutional form, but may have by-laws to meet local needs, provided they do not conflict with the general by-laws of the association.

3. The general governing body shall be drawn from the general membership, but shall in part be elected by and be representative of the several local bodies composing the organization.

4. Governing body shall work strictly within the lines of its constitutional authority, and may pass by-laws for general purposes, but all amendments to constitution, or grants of authority must be ratified by the local bodies.

5. General meetings of governing body and of the general membership may be held annually or semi-annually.

C. As a first step to bring about a federation which shall grow into a constitutional union, it is suggested:

That each society appoint delegates, one for each fifty members, to attend a convention: to draft provisional articles of federation: and that such provisional articles of federation be submitted to each society represented for ratification; and that upon the ratification by two-thirds of the societies participating, the federation shall enter upon its existence.

It may be observed that grave doubts are entertained as to the possibility of founding an organization patterned after those existing abroad, not only from the vast extent of this country and the diversified interests of various sections, but also on account of the political and social ideas, characteristic of the American people. Any general organization for the United States must respect the political habits and tendencies of the people and follow the logical growth of American institutions.

It was moved and seconded that the report be printed and laid on the table for future consideration.

Mr. Chanute then gave some details of the proposed entertainment to the Iron and Steel Institute of Great Britan, the visiting members of which would reach Chicago, October 13. It was moved to appoint a committee,—this was put to a vote and carried.

The President appointed Mr. Chanute chairman, and asked him to suggest to the chair, at his leisure, other members of the committee.

The discussion of the Railway Problem being in order, the president called upon

Mr. T. T. Johnson, who displayed a diagram showing the growth and disposition of population of Chicago. He gave the following description:

The fact has been recognized that in correcting evils of the existing railway locations in the city, it will be useful to so dispose matters as to avoid them in the future. It may be of interest to have, if it is possible, some idea of what the future may bring forth. To this end I have resurrected a diagram which grew out of a general study of Chicago's growth. Another, which has been published several times, relates to the rate of growth of population, and compares the industrial centre—not the political city, called Chicago—with other industrial centres. It leads to the inference that the population will be 2,500,000 between fifteen and twenty years from the present time, provided the precedent in urban growth elsewhere be followed here.

Assuming that the population be sooner or later 2,500,000, then the diagram may be described as being an attempt to show how it will be distributed on the area it occupies. The diagram is, of course, mainly speculative, though based on some facts, and on inferences, many of which are very logical. Among other things used as guides were the distributions of populations on the area in question for the years 1884 and 1886, reinforced since by the distribution made under the direction of the president for 1888, which I believe has been viewed by the Society. Also the known facts as to the number of persons of differing stations in life, who will live on an acre or a square mile. Nevertheless, there are many other things which governed in this attempt at future distribution of population, which is purely speculative, and on which no two persons would be likely to arrive at the same conclusion. Be all that as it may, it is probable that any one making such a diagram would have the population of urban nature extending over fully as large an area as the diagram presented contemplates. In other words, the evils of street and railway crossings will be practically continuous for from fifteen to twenty miles from the city centre, because population of an urban nature will extend to about those distances.

It is true that many of these crossings may be such as to require, individually, but little attention. For instance, the many may be such as are met with by railways passing through towns of smaller population. However, when taken collectively, and considered as being continuously met through such long distances, and being complicated by more or less continuous systems of side tracks and various commercial facilities, is it not to be concluded that, with the existing method of railway location all the crossings will be desirable subjects for correction?

Something like twenty lines of railroad now enter the city—say twenty—and concede that no new lines will be constructed. The city limits of the future will therefore contain between 300 and 400 miles of main line—essentially all independent and double, triple or four tracked. Surely they will, taken in the aggregate, be equivalent to 400 miles of independent double track. If $500,000 per mile be the cost of elevating the tracks the expenditure will foot up $200,000,000. Everything in the shape of yards, tracks, and other commercial arrangements will still be on the surface, and crossing streets at grade. And the railroads will still be crossing at grade. And furthermore, this state of affairs probably less than twenty years in the future—a rather short time when the magnitude of any remedial undertaking is considered. Do not these thoughts, speculative as they are, suggest that something more radical than this mere elevation or depression of tracks will be a necessity of the comparatively near future? Could not the city terminals pass from individual control into one terminal concern which could rearrange existing roadways, abolishing many railway grade crossings, which are really of no importance to commerce or travel, and diminishing the number of main lines in the city limits."

Mr. Max E. Schmidt then followed with a paper on the "Chicago Railway Problem.". See page 368.

Mr. Corthell in reply said: This subject of Mr. Schmidt is too extensive for a discussion to-night. It is so radical that it starts in with a confiscation of railway property, and a rearrangement that it will take a good while to accomplish, and before it is undertaken, we certainly ought to have a good deal of time to think of and discuss it. The railways themselves will be very much interested in it, and the city itself should have a voice in the matter, and the whole subject should be thoroughly discussed and studied. For one, I think we have not the facts at hand in order to

make a thorough study with a reasonable hope of accomplishment. It is hardly proper, or best for us, and it would be a waste of time to go on with a discussion of this subject when we have not at hand the facts which underlie it. Now, this is a very important subject. We acknowledge that. The railway people acknowledge it as well as we. The tracks must go up ar down, and there must be some rearrangement of them in order not to interfere so much as they do with the ordinary business of this city; the social interests of the city: the getting back and forth from one point to another without danger to life and limb. The question is, how to do it. I do not think we are ready to solve that question to-night, and with this thought uppermost in my mind, I have prepared a resolution for this meeting looking to the obtaining of the facts. We, who have given the subject any attention, and those of us who are railway engineers, certainly know that the railroads and industries, and the wharves, and the lumber yards, and the elevators, and the ordinary warehouses of this city; not only the wholesale warehouses, but the small warehouses and the little shops, the box factory, and some little coal yard, that they are all interlocked, and how to pull them apart without destroying the life of this city, is a very serious problem, and without going into any further discussion of the subject, I offer this resolution Mr. President:

RESOLVED, that a committee be appointed to consider and report upon the railway problem of Chicago in relation to terminals, rapid transit, marine commerce and related interests, under innstructions as follows:

The Committee to be composed of seven to make a final report when the work entrusted to them is completed. The outline of the work to be as follows:

1st. Preparation of a general map of the city of Chicago, and the adjacent territory involved in the consideration, showing each terminal to the limits determined, the map also to show the river, slips, docks and cable and horse car lines

2nd. Detailed maps showing each railroad within the above limits, including tracks in passenger stations, transfer yards, team track yards, lumber yards, freight houses, elevators, industries and docks, and connecting tracks with other railraods, also on these detailed maps the principal streets and cable and horse car lines, the river and slips, also bridges both railroad and street; the maps to be made on mounted paper and arranged as a set.

3RD. STATEMENT.

(*a*) Number of freight cars and tons of freight received and forwarded in 1889 by each railroad.

(*b*) Number of freight cars moved on connecting lines as, for instance, St Charles Air Line: also over nests of crossings as, for instance, at 16th, street, Stewart Avenue and the intersection of 16th, street and Canal street.

(*c*) Number of freight cars into industries, elevators, lumber yards and to steamers and sailing vessels.

(*d*) Number of passenger cars and pasengers brought in and sent out by each railroad and the same of suburban business.

(*e*) Total length of main tracks within designated limits of each railroad, length of tracks in passenger stations and in approaches to them. The same of transfer yards, local freight houses, lumber yards, docks and elevators.

(*f*) The entire area in the above limits occupied by the railroads by tracks named in "*e*"

(*g*) Estimated value of land occupied by the railroads, by lumber yards, by docks, by elevators, etc., the value of buildings upon such lands, the value of tracks and appurtenances, draw bridges, etc., with the total of the value of the entire railroad property inside of the said limits and the value in detail and in total within the following limits: west of Western Avenue, 41st street, Lake Front and Fullerton Avenue.

(*h*) Detailed statements of methods of handling business of all kinds between railroads, industries, elevators, lumber yards, teams, boats, etc. The statement to be tabulated, analyzed, grouped and shown graphically when practicable.

An estimate to be made of the cost of doing the work outlined above, three-quarters of the amount to be proportioned out among the railroad companies who have terminals in this city, the remainder to be obtained from the the city or other interested parties. The committee to employ what assistants are required to do the work entrusted to them, but the expense not to exceed the amount of the contributions.

The report of the committee to be printed and presented as soon as practicable in the coming Fall. Accurate accounts to be kept of all expenditures and a statement of the same to be rendered when the report is presented.

A spirited discussion followed the reading of the resolution, principally on the instructions appended to the resolution, participated in by Messrs. Artingstall, Corthell, Chanute, Gen. FitzSimons, Randolph and Wallace, After several amendments had been proposed and rejected, the original resolution without the instructions was voted upon and carried.

The president appointed Mr. Richard P. Morgan chairman of the Committee, and requested time to properly fill in the balance of the committee.

Mr. Corthell in presenting a resolution on an International Engineering Congress for 1893 said:

Some, and perhaps all of you, know that during the campaign for the World's Fair, there was a committee of civil and mechanical engineers appointed to further the interests of Chicago in reference to the World's Fair, and a circular was sent out over my signature at that time, October 7th. 1889

This circular was sent out to the membership of all our Societies—mechanical, civil, electrical engineers, and to our local Societies as far as the Secretary could obtain the addresses, and we received a great many encouraging responses;—not only in reference to the suitability of Chicago as a site for the Fair, but also in reference to holding here at that time an International Engineering Congress. I would like to preface this resolution which I have with a few remarks, and the gravity of the situation is such upon me that I hardly know how to explain my ideas.

This is the first time that I know of in the history of engineering—or the history of the world, that there has been a proposition to have an International Congress of Engineers. The medical men who have carried their profession along for ages, and are perhaps as old as the world itself, have their International Congress every three years, and their National Congress. Scientific bodies are united in a Congress every year. The British Association for the Advancement of Science,—The American Association,—where great bodies of Scientific men get together, and divide themselves into different sections, and discuss those subjects which they are particularly interested in with great profit and interest to themselves. And yet,—engineering is almost as old as the medical profession. You remember what Mr. Whitehouse told us,—I think he must have told it here, for I have heard him tell it many times,—about the young man who had the coat of many colors,—and who was thrown into a pit, and pulled out and taken down into Egypt,—and became a a civil engineer. His name was Joseph, and he designed and built one of the most remarkable works of engineering that the world has ever seen,—works that gave Egypt her prestige in the world for centuries, and gave her the ability to maintain her position in the arts and sciences, and in education, and enlightenment and civilization. When the works of the Civil Engineer,—by the carelessness of those that followed him,—became ruined,—and that great reservoir was broken down,—Lake Mœri dried up, and the glory of Egypt was departed. Now, it is only within the last century that there has been really an engineering profession. (See Samuel Smiles Lives of the Engineers). Most of them have gone to-day. A few only remain. They had no opportunity to obtain an education in engineering such as is given the boy to-day. They were apprentices, and down to within ten or fifteen years, that was the way engineers were brought up. In England, where there are so many remarkable men, remarkable all over the world in building harbors, railroads, irrigating works, etc., they were apprentices. It was simply a trade. We have emerged from that, and now, a young man, to attain success in engineering, has to be a college educated man. He has to know all about it. He has to have a higher education. He has to have a technical education,—and we take those young men right into our offices, without any apprenticeship, and they walk right up, and get beside us in a very few years.—just by having the discipline and education that is given in the splendid engineering colleges and schools we have all over the United States. Robert Stephenson was an accident,—you might say,—and yet, the world owes him immensely for what he achieved as a mechanical and civil engineer.

Now, we have come to a point it seems to me—members of this Society, and all the Societies in the United States, if I could speak to all—when it is proper that we should celebrate our emergence from this lower plane of a trade into a profession, by holding here in 1893 an International Congress of Engineers, to which we can invite engineers of all branches—Civil, Mining, Mechanical, Electrical, Irrigating, and Army and Naval Engineering. Let us have our sections, as the American and Scientific Associations have their sections. Let us discuss those subjects that we are interested in particularly, each one of us, and we will get good from it, not only n the way of obtaining information from our brother engineers, but also in mixing

socially as well as professionally with our brothers across the water. They know a great deal over there. I have a great admiration foi an English engineer. I met one the other day who was engaged with me in a certain work, and I traveled with him. You know when you travel with a man on a railroad train, you find out a great deal about him. That man was a son of Sir John Coode; himself a man nearly as old as I, and a man of immense experience all over the world, in opening the mouths ot rivers, building jetties, and docks, and doing that sort of work.

Now, we get together these men and discuss the subjects that we are interested in. Without wearying you any further, I will make the following motion. If we do not undertake this work quite soon, I am very sure from intimations we have had, and from the general inclination of our Eastern brethren, that they will inaugurate the same thing, and it seems to me that the Western Society of Engineers should do this work. We are here on the ground. We should entertain the delegates from other countries, and from our own country, for that matter, and should act as managers of this Congress as far as the arranging for it is concerned, and some action, whether this that I have outlined or not, ought to be taken if we are going to do anything about it. The following is the motion:

A committee of five to be appointed on an International Engineering Congress to he held in Chicago in 1893, and to report at a special meeting two weeks from to-night.

This committee to be instructed to organize a general committee, and to be empowered to take all necessary steps which, in its judgment, are necessary foi the early organization of such a committee.

The instructions to the preliminary committee to be as follows, as to the organization of the general committee:

Composition of the general committee to be five members of the Western Society of Engineers—the preliminary committee appointed under the motion to be these five members. Three members to be appointed by each national society of Civil, Mechanical, Mining and Electrical Engineers: One member to be appointed by each local society of recognized standing in the United States. One member from important sections of the country where no engineering society exists; these last appointments to be made by the preliminary committee. The Chief of Engineers of the U. S. Army to appoint one Army Engineer and one Naval Engineer to be appointed; each member of the general committee to have an alternate.

The general committee to organize as soon as possible after it is instituted; its Chairman to appoint an executive committee of thirteen, five of whom and the Chairman, must be members of the Western Society. The executive committee to request all foreign societies of engineers to send delegates to the Congress, and the preliminary committee to issue an address and distribute in the United States and foreign countries, outlining the general purpose and scope of the Congress.

The instructions appended to the motion were again a bone of contention.

It was finally voted that a committee of five be appointed on an International Engineering Congress to be held in Chicago, 1893, and to report at a meeting to be held two week from to-night. Mr. Corthell was appointed chairman of the committee.

A resolution was passed at the last meeting of the society indorsing the action of the Civil Engineer's Club of St. Louis, in reference to erecting a statue of the late Capt. Jas. B. Eads. Mr. Corthell, who was not present at that meeting was desirous of emphasizing the resolution, and upon being called said:

It is work of love, respect and admiration for me to speak of a man with whom I was associated from 1874 until his death, in 1887; most of the time very intimately in his engineering works, and associated with him personally as a friend. I knew him as well as any engineer knew him. I knew him better than many of his intimate friends, because I was with him months at a time, when there was struggle to obtain the right to do the engineering work, and then struggling on the work itself, and in order that the life of so busy a man might be stated in a few moments to you, I have condensed it into a few pages.

Mr. Corthell then delivered a most eloquent eulogium, which will be printed in an early issue of the Journal.

He afterwards explained the status of the matter as communicated to him from St. Louis, and suggested, without offering any new resolution, that the matter of subscriptions be left for the present, and that such members of the society as would wish to enroll themselves as members of the Association give their names to the Secretary to be forwarded by him to St. Louis. It would appear that a general subscription would be preferable to a few large ones, so makingthe matter more national.

The meeting adjourned to meet again in September—after the special meeting.

John W. Weston, Secretary.

SPECIAL MEETING—INTERNATIONAL CONGRESS. 271ST MEETING, JUNE 18th, 1890. The special meeting of the Society was called to order at 8 p. m. by President L. E. Cooley, with some 35 members present. The president briefly explained the object of the call and requested the secretary to read the minutes of the last meeting referring to same.

The secretary then read, for the chairman, the report of the committee on An International Engineering Congress, as follows:

CHICAGO, June, 18, 1890.

To the President of the Western Society of Engineers.

MR. PRESIDENT: The Committee of the proposed International Engineering Congress, to be held in this city in 1893, during the World's Columbia Exposition, presents the following report:

We are decidedly of the opinion that such a Congress should be convened. It is eminently fitting that Engineers, representing the various branches of Engineering, should be called together from all parts of the civilized world on the occasion of the celebration of the 400th anniversary of the discovery of this continent: to not only consider the many great works which our profession has performed for the use and convenience of man, but to learn from each other much that will be of mutual benefit; to obtain a concensus of opinion on many important principles and projects now in process of development; and, finally, to hold that extended social intercourse enjoyed by engineers only on such rare occasions. While these reasons refer largely to the advantages of such a Congress from an international point of view, we are deeply sensible of the necessity and importance of bringing together the various but almost distinct branches of engineering of our own country, in order that we may come, for the time at least, into more cordial sympathy and learn from each other much of importance in those branches in which each is expert.

The scope of the Congress should be broad, including all branches of Civil Engineering, in its divisions into Civil (distinctly so known), Mechanical, Mining and Electrical Engineering, also Military and Naval Engineering.

Engineering Societies in other countries should be asked to send delegates to the Congress, and Governments themselves should also be requested to send representatives.

We recommend:

1st. That this Society initiate the peliminaries for the Congress by requesting each of the National Societies—the American Society of Civil Engineers, the American Society of Mechanical Engineers, the American Institute of Mining Engineers, the American Institute of Electrical Engineers, and Canadian Society ot Civil Engineers—to appoint a committee of not more than five members (two at least, of which shall be residents of Chicago, or vicinity), to meet in this city on Oct. 1, of this year with a committee of seven of this Society, for the purpose of formulating the plans for the Congress.

2nd. That all local engineering Societies ot the United States and Canada, of recognized standing, be requested to send to this meeting, committees of not more than three delegates, and that the committee of this Society be authorized to appoint, as delegates to this meeting, one or more engineers from those sections of the country that have no engineering organizations.

3d. That the committee of this Society be instructed to confer at once with the proper committee of the Exposition, with the view of arranging for the Congress to be held under the auspices of the Exposition, and under its general management.

4th. That the correspondence be conducted in the name of this Society and by its Secretary, who shall represent this Society during all of the proceedings, and who shall also act as Secretary for the Committee to be appointed as herein provided.

In conclusion: the necessity and duty rests upon this Society to perform in a large measure the laborious work required to convene and organize the Congress. While the work may be in immediate charge of a committee, every member of the Society should be ready at all times to assist in any way that lies in his power.

We strongly recomend immediate action by this Society, and the appointment at this meeting of a committee of seven, which shall be instructed to prepare and send out, without delay, a circular letter to the national and local Societies of the United States and the Dominion of Canada.

Respectfully submitted by your commiitee.

E. L. CORTHELL,
O. CHANUTE,
D. J. WHITTEMORE,
BENEZETTE WILLIAMS,
CHAS. FITZSIMONS.

The above report is given as slightly amended by motion and vote.

Prof. H. B. Herr spoke at length on the magnitude of the undertaking and the difficulties and differences which might be encountered in bringing the other national Societies into line, but expressed himself in favor of the project.

In reply to a remark by Prof. Herr relative to the congress being held under the auspices of the Exposition:

Mr. CORTHELL said: Mr. Chanute and Mr. Whittemore have both had experience in this matter, and know all about it. There were forty-six congresses held at the Paris Exposition, and all under the auspices of the exposition in order that there mtght be no clashing, and that these congresses might come at suitable times and not all together, and might be in their action and management harmonious, and they were really under its auspices. Both these gentlemen insisted upon it that we should at once see the proper committee of the exposition and not proceed in a public maner, or take any steps towards the convening of this congress until we had had a conference with them in the matter, and it is understood that we wish to have the Congress under its auspices, and look to them for their suggestions and advice largely in convening and managing it.

The question was put and the report was unanimously adopted as the sense of the Society as amended.

The president then, by motion of Prof. Herr, appointed Robert Forsyth and C. L. Strobel to complete the committee.

After adjournment Mr. CORTHELL said: The Society has adjourned and I would like to bring up a matter informally, and I would like to do it now, if the gentlemen will wait a minute. I received a letter to-day in reference to the Eads monument matter, which was up at our last meeting, and it was a little doubtful then as to what steps had been taken, and what the arrangements were, and how far the thing had gone. Mr. Meier, who is one of the executive committee writes this letter bearing on the subject: Our plans in outline are about this: The Executive Committee is to go over the ground carefully during the summer months, select one or two proper sites. Bridge Square would be the best, but over that hangs a franchise for an elevated road which will probably never be built, but which would be in the way of building a monument where it might, later on, be obscured by such a structure. Of course the site will influence the character of the design, and must be considered by the artists.

Our next move will be to properly prepare subscription books during the summer months, and not commence an active campaign until September, since many of our wealthiest citizens who may be expected to contribute largely are away at the watering places, or in Europe during the hot weather. I feel that the matter is of such general interest, and is so well received that we shall have no difficulty in raising the required amount. This we place at from $15,0 0 to $18,000.

Two general ideas regarding the style of the monument have been suggested. One is the statue of Eads in heroic size, placed on a suitable architectural base. The sides of this base might contain bas-reliefs showing portrait figures of Eads and some of his co-adjutants in his great work—the gun-boats, the bridge, the jetties and probably the inter-oceanic railway. Another idea of the pediment might be a drinking fountain running from one face freely, leaving the bas-relief on the other three faces, and above the fountain an allegorical figure of the great river, with the motto, "Through his efforts I flow freely to the sea." Another idea would be simply a collossal bust of Eads, set on a pyramid of rough boulders which might be contributed by various foreign and American societies. This idea has for it the fact that it is always difficult for an artist to make much of our modern garb in a statue, and Eads in a Roman toga would look absurd. My idea is that Eads was a strictly practical, energetic, modern man. It would be difficult to find a finer product or blossom of the civilization of our country, and everything about his monument should emphasize this fact. He can be planted firmly on the nineteenth century, and needs to borrow nothing from past traditions.

So far, we have as the beginning of our funds, the proceeds from the concert by the Liederkranz, and a voluntary contribution gathered by three little school boys in Miss Dozier's private school here. We shall probably do nothing in the way of an active canvass for subscriptions before September, and would be very glad to get any suggestions that may occur to you."

I think they would be very glad to obtain the names of those who would like to be members of the Association, and any who feel inclined to become such, without any obligation to contribute, can give their names to the Secretary, as was arranged at the other meeting. It would be gratifying to our St. Louis brethern to know that we are taking some interest in the matter.

JOHN W. WESTON, Secretary.

ASSOCIATION OF ENGINEERING SOCIETIES.

ORGANIZED 1881.

Vol. IX. August, 1890. No. 8.

This Association, as a body, is not responsible for the subject matter of any Society or for statements or opinions of any of its members.

FERROID, A NEW ARTIFICIAL STONE.

By Herman Poole, Member of the Civil Engineers Club of Cleveland.

[Read June 10th, 1890.]

Ferroid, as its name suggests, is like iron—in color, expansion and many other properties, and contains proportions of that metal varying from 25 to 33 per cent. It is a compound, partly chemical and partly mechanical, of the elements iron, sulphur and silicon, with more or less foreign matters; and from the union of these elements a material is obtained having some properties of each of its constituents, besides others possessed by neither.

It is mainly a super-saturated solution of iron in the sulphur, with the silica acting as a binder and hardener. The form of the crystals is entirely different from that of sulphur or iron in any of their states, and the melting point is midway between that of its constituents.

Before mentioning any of the uses it may be well to give a succinct account of some of its physical and chemical properties, as by so doing a fuller comprehension of such uses and applications will be possible.

COLOR.—The usual color is that of a dark slate. This color is lighter on a fractured or coarsely tooled surface and much darker on a polished or varnished one. It then approaches black or plumbago color. Being thus of a dark color naturally, attempts to make light tints are futile, but many colors of a medium tint are possible, besides the darker ones. The pigments used must be of a kind not affected by the action of sulphur; of such nature are the earthy pigments which work well, although being of weak tinctorial power large proportions are needed.

Imitations of the color of various kinds of brick and sandstone have been successfully made, also the various mauves, dark drabs, slates, dark greens, etc. These tints and the natural one being of the neutral kind

harmonize well in combinations and can be used to produce very pleasing effects.

HARDNESS.—The hardness is comparable with stone and brick, and is about that of ordinary bluestone. It is quite tough for the class of material, being capable of working under hammer and chisel, drill, or even being turned in the lathe or planed with a planer. It is thus much tougher than ordinary cements and most artificial stones. The colder it is the tougher in working.

SURFACE.—The surface is smooth or rough as desired, depending on the proportions of the materials used and much more on the surface of the mould in which it is cast and the character of the finish imparted to it. Any of the different styles of finish may be given it which are applied to cut stone, even to a polish as smooth as glass; in fact the polish of plate glass may be easily transferred to it and on microscopical examination all the fine scratches are shown reproduced on the ferroid.

ELASTICITY.—The elasticity is slight but measurable, the elongation under tensile strain very low. Resistance to tensile strains is quite high for the class of material; strains of from 750 to 1,200 pounds per square inch having been resisted in test pieces of one inch sections. It compares very favorably in this respect with the natural and artificial stones as well as the cements. It possesses the advantage of uniformity in composition and hence it is possible to have large quantities with the same strength.

COMPRESSIBILITY.—The compressibility is very slight but resistance to compression is high, being from 9,000 to 12,000 pounds per square inch in test pieces 3″ square; in one instance 15,000 pounds per inch was sustained, without crushing. This enables it to hold successfuly as large weights as can be applied to any of the stones used in building and places it far beyond the strength of the common cements in use as few of them ever equal the strength of the stones they are used to bind.

It shows no tendency to bend under pressure and breaks with a columnar fracture.

ADHESION.—It is very adhesive to anything that presents points of contact and to many substances which are nearly smooth. It will adhere to glass and glazed surfaces while hot. The force of adhesion to brick, stone, wood or iron is that of several hundred pounds to the inch; to cast iron the strongest of any.

This adhesion to cast iron is shown in the case of a conical cast iron plug being cemented with ferroid in a ring of cast iron. The thickness of the cement varied from one-half to one inch and the diameter of the plug was six inches. A force of 150,000 pounds was applied without starting it or even showing any signs of compression.

This adhesion is manifested also under transverse or shearing strains in brick and stone joints. In the case where ferroid was used as a cement for pavement blocks one of the stones was broken by a sledge-hammer in futile attempts to drive it through.

In another instance, thirty-two ordinary bricks were cemented together side by side and supporting the two end bricks on props, a weight of 150

pounds was held up at the middle. The whole was then supported while the end brick was cemented to a wall, and on taking away the supports the line not only remained unbroken, but the deviation from perpendicular to the wall was hardly appreciable.

Although ordinary liquids have no adhesion to a smooth ferroid surface, viscid, oily substances adhere well and can be spread smoothly. The surface thus becomes available for many applications needing oil paints, in fact, it forms one of the best surfaces for oil painting, and many times has been used for such purposes—a fine, smooth painting being the result. In many of the uses in a large scale this property becomes convenient as lettering or painting of more or less of the surface is often desirable, in some cases indispensable.

POROSITY.—Having a solid, uniform, homogeneous texture, water or other liquids, and even air or gases have no passage into or through it. The thickness of one-sixteenth of an inch has repelled a pressure of twenty pounds of water. A polished surface presents a firm front like polished steel to all attempts of liquid penetration, and one on which they get no hold, and through which a pressure of 300 pounds to the inch has been unable to force them. This applies to steam pressure as well as air pressure; a force of 80 pounds steam with its accompanying temperature having been successfully sustained.

WEIGHT.—The specific gravity is about 2.6, being thus one-fourth as heavy as lead or one-third as heavy as iron. Ordinary sandstone will float on melted ferroid, although it becomes nearly submerged when all the air is expelled from its pores. The weight varies a little with change of composition, but it is safe to estimate 1 cubic foot as 170 pounds; 1 cubic inch as 0.1 pounds; 1 flour barrel, full, as 600 pounds.

ACTION OF HEAT.—It is a very poor conductor of heat. The thickness of $^1/_{64}$ inch being sufficient to protect the hand from danger of burning from the melted ferroid, or even from a temperature of 400°. This property is also shown in the use of the material in taking casts from the moulds.

It melts at about 300°, and melts very slowly at first, requiring a low fire. This is owing to its low conducting power. When melting, it is necessary to keep it well stirred, especially at first, later on an occasional stir will suffice. At the first application of heat no softening occurs until the melting point is reached. Then it melts to a thin liquid—nearly as thin as water and remains so if the heat is not increased. On increasing the heat a gradual thickening is noticed, until finally it becomes as thick as mortar, or even thicker, and can be stirred only with difficulty. If, now, it be allowed to cool, a gradual thinning occurs until the former watery consistence is attained; this it keeps until solidification.

While solidfying, the whole mass becomes a conglomeration of feathery leaf-like crystals intricately woven together. This crystal structure is entirely different from the sulphur crystal, and undoubtedly is the cause of the high tensile strength. On cooling, a gradual contraction takes place, as with cast iron, until the whole mass is nearly solid. Then a slight expansion occurs, followed by a small contraction as it gets cold.

The expansion seems to be occasioned by the whole mass assuming the crystalline form, and the subsequent contraction is that due to the general law of expansion and contraction. The contraction after setting is about that of cast iron, slightly less.

ACTION OF ELECTRICITY.—Being a non-conductor of heat, it would be supposed to act in a like manner towards electricity, and such is found to be the case. Tests made with bars of ferroid 14″ long, 1½″ wide and ¾″ thick showed a resistance of ∞, ∞ and 125,000,000 ohms. This test was made after the bars had been soaked in water for 36 hours. These tests place it in the front rank among insulators along with vulcanite shellac, etc., in fact, places it ahead of them.

ACTION OF AIR, ETC.—Gases having no apparent adhesion to ferroid surface if smooth, have no action on it and pieces exposed to the action of the weather for several years have shown no diminution of polish. The effect of ordinary climatic changes is not to disintegrate it, as for this it is necessary for moisture and its winter form of frost to penetrate the mass. This it cannot do, and consequently has no effect beyond a blurring of the polish, which is readily removed with wiping. Rain striking it glances off as from an oiled surface. Usually, the capillary attraction of water in a vessel of ferroid is exerted in the negative direction, as with mercury in glass, the meniscus being reversed.

MIXTURES.—Ferroid can be mixed with almost anything which is dry. Any of the earthy materials, sand, gravel, rubble, clay, lime, brick-dust, dried earth, etc., work in well. Some of them seem to have no effect on the strength, unless used in very large proportions. It is capable of uniting very large proportions of sand or gravel without sensible diminution of strength. The earthy or fine materials weaken it more.

Asphalt, tar, sulphur and like materials can be incorporated with it, some needing more care than others. The resulting mixture is between the elements in properties, and some of these mixtures are very valuable. With tallow and fatty matter no mixture can be had.

APPLICATIONS.—As may be readily supposed from the above recital of the properties of ferroid, the applications are numerous and valuable. A few only will be mentioned.

First. Let us consider it as a material capable of melting, and hence of being cast in a mould. This is possible with almost any kind of a mould; moulds of glue, plaster, wood, stone and metal having been used. Moulds of sand may be used, but it is not ordinarily desirable, as the surface is very rough, and owing to the tenacity with which the sand is held, it is very destructive to tools used in dressing.

Ferroid is probably the only hard substance which can be melted and poured into a glue mould without spoiling it. This has been done repeatedly and with complicated forms. The action is peculiar. Of course the glue melts with the heat of the ferroid; but before this occurs a thin skin of solidified ferroid has been formed on the surface of the mould, which, by its strength, prevents the liquid mass from breaking through, and by its low conduction prevents the glue from melting quickly. The glue is hence held in place and melts very slowly, and by the time the

glue is melted soft, the ferroid is set and hard enough to bear its whole weight and keep the glue in place. On cooling, the glue re-casts itself on the ferroid, and when quite cold it may be stripped off as good as new.

With plaster moulds and also with wooden ones care must be taken to avoid air bubbles, or blow holes as these become magnified in the cast owing to the expansion of the air under heat. This does not apply so forcibly to metal moulds, as they are generally comparatively smooth.

With all moulds, except those which are highly polished, the use of some greasy or waxy material is necessary, owing to the strong adhesiveness. Paraffin wax or heavy lubricating oil seems to answer the purpose best. Only enough need be used to prevent contact, as more would blurr the impression. In some cases plumbago or facing may be used either alone or supplementary to the wax or oil. Even with highly polished surfaces it is well to have a very thin film of oil, which is best obtained by lightly wiping over with an imperfectly oiled rag.

In making hollow casts some provision must be made to remove the core from contact with the solid ferroid before the contraction sets in. In conical or conoid moulds this is easily effected by withdrawing the core slightly—an inch or so being sufficient. With other forms collapsible cores must be used.

When making casts it is usually advisable to heat the mass above the melting point, with brisk stirring. Then remove the vessel and let it gradually cool down till of the proper consistence for pouring.

It must be remembered that whatever form is made it can be used over again and again, as remelting does not deteriorate but rather improves it. All broken pieces are as good for remelting as new material.

Among small objects may be mentioned the numerous statuettes, vases, medallions, picture frames, etc., to be found in our drawing rooms, and *insulators* for telegraphic or other electric wires. These latter may be cast smooth or with thread, either inside or outside, or both, and being hard cool, not acted on by the elements or chemicals, and of high resistance, may be used to advantage in all places where an opaque insulator is admissable. One was tested in the office of the Western Union Telegraph Company, at New York City, by being placed in water, the inside being dry. A force of 10,000,000 ohms was needed to pass the current through the sides which were ⅛″ thick in thinnest part.

MUGS, PITCHERS, COCKS, TUBES, etc., which are in constant use in chemical works, may be made of ferroid and do good service. BATTERY TOPS for closed cells and the numerous other places where vulcanite or its equivalents are used can be supplied with ferroid at a decided reduction in cost, but no reduction in insulation.

Among larger castings may be mentioned PIPES for sewage or other purposes. It is eminently adapted for this use, requiring no skilled labor at the ordinarily difficult pieces and being capable of ornamentation in any way desired at no extra trouble in casting. As soon as the form is out of the mould it is ready for shipping and no delay in preparing, drying and firing is needed. The pipes are not porous and may be had polished if needed. They have no honeycomb structure and small

bubbles due to defective moulds never extend into the body of the pipe. They can be cast in the ordinary or special shapes readily, and are always of uniform strength.

CHIMNEY TOPS have been used in several instances and cost much less than any made from stone. They answer well and are very durable. The temperature at the top of an ordinary house chimney never reaches anything like the melting point of the ferroid. They may be made of very artistic forms as readily as of simple ones.

For black-boards a very decided advantage over slate is obtained in price. They always have grit enough and do not get gummy. They can be put up much thinner than slate ones. They wear as long as the school-house.

BILLIARD TABLE TOPS are cast with smooth top and bottom, and require no polishing. They resist the usage well and cost much less than slate.

SANITARY APPLIANCES.—Such as water closets, urinals, basins, bath tubs and the like have been made and possess many advantages. They are clean, almost self purifying. They are not porous and furnish no foothold for disease germs. They are cheap.

VATS AND TUBS—Can be used for any purpose, water, chemicals or electro-plating. They may be made with or without holes or taps and can be changed as desired, holes being easily stopped up or drilled out.

ARCHITECTURAL FORMS.—Caps, cornices, sills, keystones, corners, bricks, whole arches in fact, or columns may be made, either in moulds, or *in situ* if needed.

Many other forms could be mentioned but will readily suggest themselves to a practical man.

Core makers, having intricate cores to make, have occasionally availed themselves of ferroid by making a model of the core in wax, wood or plaster and pouring ferroid over it. A mould is thus made which will outlast many of the ordinary wooden ones.

Occasionally blow-holes or sand-holes are found in cast iron and in some instances to save breaking the casting these holes were filled with ferroid. In one instance, in a trip hammer block after being painted over, it not only did not show but six months wear did not loosen it.

Second. Having considered the applications depending on its melting let us now consider some which come from its adhesive properties in addition.

In this connection attention is at once drawn to its immense advantages as a building material for concrete, etc, any kind of stone, any kind of gravel may be used and it will unite them so firmly that in many instances the stones themselves will break before leaving the cement. Of course any application of concrete of any other kind can be filled by this with the proviso that the materials used and the surfaces applied be dry at the time of the applications, once thoroughly united no water or moisture will ever get in and hence no crumbling from such cause.

A very large amount of filling in the shape of sand or broken stone and gravel may be used without weakening the mass, as it seems that

only ferroid enough to unite the stones firmly together is needed, no especially large body of cement being required.

Any desired form may be given the concrete by means of suitable moulds and it may be moulded into blocks or used as a continuous mass *in situ*.

CULVERTS AND BRIDGE FOUNDATIONS.—May be cited among the numerous applications of this concrete and the surface imparted to them may be rendered perfectly smooth thus lessening the friction of the water and in the case of culverts enabling a small cross section to be used. They are as strong and durable as stone and have no attraction for moss germs or other vegetable growths, which have a tendency to choke up the openings.

Another form of concrete is that used in making floors for stables, breweries, chemical works or other places requiring a strong, hard, durable, impervious floor, not affected by heat or cold, rain or shine, steam, moisture or ordinary chemicals.

The same or analogous composition used for floors may be used as a facing for walls; there are many cases where a wall has been laid with ordinary mortar or cement and the water on the outside persists in going in or the inside persists in going out through the wall. An application of ferroid made plastic with a large quantity of sand will remedy this. If the surface of the wall can be made dry or approximately so the ferroid will stick to it, and once on no further trouble will be had from water on either side. In this way leaky cisterns, vats, chimneys and other brick work may be rendered tight. It will stick to wood but not as firmly as to brick or sandstone.

As a simple cement, it has been applied to joints of sewer pipe and some kinds of water pipe with success. In one instance, a line of water pipe had 300 pounds of water turned on in fifteen minutes from the time of pouring the joints and no leak discovered, of course with ordinary kind of ferroid no caulked joints can be made. With iron pipe uniform success has not been attained, but this will probably be had with a better understanding of the material, and how to use it.

It has been used as cement for bricks in many places. Its strong adhesion to this class of material was shown above. The outside course of ordinary chimneys has been laid with it and in case that portion projecting above the roof very good results have been attained, especially in locations where strong winds tend to overturn them.

Allied to this class of structures may be mentioned towers of brick erected for chemical purposes, for which it is well adapted by its strength, absence of pores and resistance to chemical action.

Underground cisterns, vats, cellar walls, and the like, when laid with it have the advautage of its strength and eminently its non-absorbing properties.

Several thousand yards of stone pavements have been laid using ferroid as a cementing material, and after several years use but slight wear can be noticed. Its high mleting point added to its not softening under that temperature gives it a very decided advantage over other sub–

stances used for such purposes. It does not get brittle by cold. It is non-absorbent, germ-destroying, clean and durable.

It requires a force of 400 pounds to the inch of surface contact to shear a stone out of its bed and in many cases efforts to drive one out with a sledge hammer have resulted in fracturing the stone, but not starting it. As it wears a little faster than the stone a good foothold is always possible for the horses.

RESULTS OF TESTS MADE.

The majority of these tests were made at the testing department of Fairbanks & Co., New York City. Some of the others were made with Riehle & Co.'s machines.

NO.	COMPOSITION.	KIND.		LBS. PER INCH
1.	Ferroid........................	Compression		9073
2.	1 Ferroid, 3 Sand............	"		11303
3.	1 Ferroid, 3 Sand, 6 Stone Chips	"	(sideways.)	3756
4.	Ferroid........................	Iron Ring compression,		15000
5.	Ferroid........................	Tensile,		750-1050
6.	1 Ferroid, 3 Sand...............	"		850
7.	1 Ferroid, 1 Asbestos.	"		1050
8.	Ferroid........................	Transverse,		1322
9.	Ferroid........................	Adhesion to iron,		526
10.	Ferroid........................	"	stone,	431
11.	Ferroid........................	"	brick,	420
12.	Ferroid........................	Pressure (steam),		75

13. Exposed to action of gas in main. No action on the Ferroid.
14. Boiled in dilute sulphuric acid. No action.
15. Boiled in Muriatic acid. No action.
16. Boiled—mixture of soap-suds, nitre and soda. No action.
17. Electrical resistance........................125,000,000 Ohms.

COMPOUND LOCOMOTIVES.

By Arthur T. Woods, Member Engineers Club of St. Louis.

[Read May 7th, 1890.]

While the compound locomotive is not a new invention, it is only within a year that any genuine interest in the subject has been developed in railroad circles in the United States. The American Master Mechanics' Association at their meeting last June, regarded the subject of compound locomotives as sufficiently important to be made one of the leading subjects for investigation and report. The railroad technical journals have been for several months devoting a large part of their space to the illustration and discussion of the various types. And while there are at present but two compound locomotives in actual service in this country, so far as known to the writer, one on the Michigan Central Railroad and the other on the Baltimore and Ohio, it is known that a number of railroad companies and locomotive works are building compound locomotives or are preparing designs. So it will be seen that we are at the present time in a state of agitation and experiment.

In some countries, however, the compound locomotive may be said to have passed beyond the experimental stage and to be an assured fact. There are approximately 175 compound locomotives at work in Great Britain, 160 in Germany, 45 in Russia, 100 in South America and smaller numbers in France, Italy, and India. In all, about 500 have been reported in papers before Engineering Societies and by the technical journals, and as some of these reports are over a year old, it is probable that this figure is below the number actually in use.

Evidently the compound locomotive is considered to be a success by many engineers, but it is also true that among railroad men there are many who regard it with suspicion, to say the least, while some have no use for it. The reason for this opposition, or antagonism as it really is in some cases, is not apparent on the surface. If the proposition to use compound locomotives were mentioned to an engineer, who is not a railroad man, but who is familiar with recent progress in marine and stationary engines, it is probable that it would seem a very simple question to him and he might wonder that compound locomotives had not been used before. In marine work we find triple or quadruple expansion engines almost without exception, and the compound engine, which not many years ago was investigated by a Board of Naval Engineers to decide whether or not it could be advantageously substituted for simple engines in naval ships, has been relegated to steam launches. But the locomotive uses just about as much steam per horse-power as it did 30 years ago.

Not that it has not been improved during that time, for great advances

have been made in locomotive engineering. But the improvements have been principally in the boiler and in various attachments. The steam pressure is higher, the locomotive is heavier, the cylinders are larger, but it is still a simple engine with a slide valve, and therefore compared with compound engines is uneconomical.

The compound locomotives of to day may be said to be the direct successors of three small two-cylinder compound locomotives which were built in 1876 for the Bayonne and Biarritz Railroad from the designs of Mr. Anatole Mallet, of Paris. These locomotives were successful from the first and were soon followed by others for the same road. In 1878, Mr. F. W. Webb converted an old locomotive into a compound on Mr. Mallet's system, and the satisfactory results obtained with this engine led to the now well-known Webb three-cylinder compound. The first of these was built in 1882 and there are now about 95 locomotives of this type in use, principally on the London and Northwestern Railway of which Mr. Webb is Chief Mechanical Engineer. In 1880, Mr. A. von Borries designed a two-cylinder compound locomotive for the Hanover Railroad, (Germany) which was followed by others, and in 1885 Mr. T. W. Worsdell then of the Great Eastern Railway, (England) brought out a design similar to that of Mr. von Borries. Other engineers have done much to develop the compound locomotive, but Messrs. Mallet, von Borries, Webb and Worsdell are to be especially credited for having established the types or systems which are now generally known by their names. As illustrative of the way in which a new idea gains ground, it may be noted that in 1886, ten years after Mr. Mallet's first compound locomotives, there were but 60 compound locomotives in existence, while to-day there are not less than 500.

The majority of these locomotives have two cylinders, but locomotives with three and four cylinders are in use. and the two, three or four cylinders have been arranged by the designers in about as many ways as is possible. The two-cylinder engines may be divided into two general classes which are known as the Mallet and the Worsdell-von Borries "systems". In both of these, the cylinders are placed as it is customary for simple locomotives, either outside connected as all American locomotives now are, or inside connected following the custom of a number of European railroads. The only difference from the simple locomotive in appearance is that one cylinder is larger than the other, and this apparent difference is frequently lessened by building out the lagging of the high-pressure cylinder until it is over-all the same size as the low-pressure. The exhaust steam from the high-pressure cylinder passes to the low-pressure cylinder through an arched copper pipe which thus forms the receiver and which is placed in the smoke-box. The cranks are of course at right angles. and this form of compound locomotive is therefore simply a compound receiver engine. Mr. Mallet's idea has been from the first that the locomotive should be so arranged that it can be worked as either a compound or as a simple engine at the will of the engine runner. To accomplish this. valves are inserted in the high-pressure steam pipe and in the receiver pipe by means of which live steam from the boil-

DIMENSIONS OF COMPOUND LOCOMOTIVES.

	Swiss. Mallet.	England. Worsdell.	Prussia. V. Borries.	Saxony. Lindner.	Saxony. Lindner.	England. Worsdell.	Russia. Urquhart.	Mich. Cent. Pitkin.	France. No. Ry.	England. Webb.	France. P. L. M.	France. P. L. M.	France. No. Ry.	B. & O. Vouclain.
Number of cylinders	2	2	2	2	2	2	2	2	3	3	4	4	4	4
Diam. h. p. cylinder, inches	17.7	18	18.1	16.6	18.1	18	18.5	20	17.(1)	14.(2)	12.2(2)	13.4(2)	14.9(2)	12.(2)
Diam. l. p. cylinder, inches	25.6	.6	25.6	23.6	25.6	.6	25.6	29	19.7(2)	[illegible]0.(2)	19.7(2)	21.3(2)	25.7(2)	20 (2)
Stroke of piston, inches	25.6	24	24.8	22.1	24.	24	24	24	27.6	24	24.1	25.6	2[illegible].6	24
Number of driving wheels	6	4	6	4	6	2	6	6	6	4	4	8	8	4
Diam. of driving wheels, inches	58.4	86¼	52.4	75	55.6	85¼	51.	68	64.9	75	78.7	59.1	51.2	66.
Weight, working order, total lbs	79,350	97,000	88,2[illegible]0	91,287	90,294	96,0[illegible]0	80,640	126,800	106,176	99,350	117,950	12[illegible],450	11[illegible],987	105,000
Weight, work'g order driv. wh'l's lbs	79,350	68,000	88,250	63,[illegible]82	90,294	40,320	80,640	97,000	90,144	66,700	6[illegible],260	125,[illegible]0	113,[illegible]8[illegible]	72,000
Boiler pressure, lbs. sq. in		170	174	176.4	176.4	175	135	18[illegible]	199	175	213.3	213.3	14.2	165
Ratio of cylinder volumes	2.09	2.08	2.	2.	2.	2.08	1.92	2.1	2.68	2.3	2.6	2.53	3.	2.78

er can be admitted to the low-pressure cylinder, while at the same time the exhaust from the high-pressure cylinder passes directly to the exhaust nozzle. The pressure of the steam which is admitted to the low-pressure cylinder is reduced by means of a pressure reducing valve or simply by wire-drawing, to about one-half of the boiler pressure so that each cylinder does approximately one-half of the total work. With this combination of valves the locomotive may be operated as a simple engine as long as may be desired.

Mr. von Borries and Mr. Worsdell wished to avoid the complication which is unavoidable in Mr. Mallet's system, and also to make compound working compulsory upon the engine runner in order that the economical advantages of the compound engine might be insured. To accomplish this, and at the same time to utilize the full power of the low-pressure cylinder in starting, an intercepting or non-return valve is placed somewhere in the receiver pipe, but no separate exhaust is provided for the high-pressure cylinder. The action of this valve is such that the locomotive practically starts as a simple engine but soon begins automatically to work as compound.

Mr. Lindner has adopted a still more simple device for two-cylinder compound locomotives in Saxony, which consists essentially of a small pipe and cock for admitting boiler steam to the receiver, without the addition of an intercepting valve or other complication. With this arrangement, the locomotive is practically always worked as a compound, as even in starting this receiver pressure is back pressure on the high-pressure piston as well as forward pressure on the low-pressure piston.

The Webb compound locomotive has three cylinders, two high-pressure which are connected to one driving axle, and one low-pressure which is connected to a second driving axle. The most noticeable peculiarity of the system is the absence of connecting rods. Another form of three-cylinder compound locomotive is that built by the Northern Railway of France, which has one high-pressure and two low-pressure cylinders. All three cylinders are connected to the same driving axle and all three driving axles are coupled.

Other French railroads have recently built experimental four-cylinder locomotives, several of which have two inside connected high-pressure cylinders and two outside connected low-pressure cylinders. The complication of such an arrangement is necessarily very great compared with ordinary locomotives. In another form of four-cylinder compound there are two cylinders on a side arranged tandem, the low-pressure cylinder being in front. The high and low-pressure pistons are connected to one crosshead and the steam distribution for both cylinders is controlled by one slide valve. The Baldwin compound for the Baltimore and Ohio Railway also has four cylinders, two on each side. The high-pressure is directly above the low-pressure, both pistons are connected to the same crosshead, and one piston valve governs the steam distribution in both cylinders. Mr. Mallet has designed a form of four-cylinder compound which resembles the the Fairlie locomotive. The two high-pressure cylinders are attached to the rear part of the main frames and are connected

to one set of driving wheels and the two low-pressure cylinders are mounted on a bogie with a second set of driving wheels. Small locomotives of this type were used at the Paris Exposition, and one of the heaviest locomotives in the world, for the St. Gothard Railway, is built on the same plan.

Before discussing some of the special advantages and disadvantages of these different designs, I would call attention to some of the more marked differences between the requirements which must be fulfilled by locomotives and by engines for other classes of work. A marine engine, for example, is expected to develop its full power, or very near it, the greater part of the time. The engine is designed to develop a certain horse power at a certain speed and with a certain degree of expansion and it is not expected to work for any great length of time under very different conditions. The locomotive, on the contrary, is required to work under continually varying conditions, on a level and on grades, in good weather and bad, and with considerable variations in the weight of the train. To accomplish this, it must be capable of doing satisfactory work with widely different rates of expansion, must do its ordinary work with economy, and must have considerable reserve power. Then the question of starting is comparatively of small moment in marine engines. But the locomotive must be able to develop its full tractive power in starting and it must not be possible to stop it in such a position that it cannot start itself promptly.

In marine engineering, considerable complication is admissible if a saving in fuel is thereby secured, but in the locomotive simplicity is essential as the mechanism cannot be carefully watched while the engine is in motion. The question of the total weight and the distribution of the weights is important in both marine and locomotive work although in quite different ways. There are of course many other items to be considered, as there are in all problems in steam engine design, but enough have been mentioned to show how widely the requirements of locomotives differ from those of marine engines, and the same will hold to a great extent in comparisons with the various classes of stationary engines. In view of these considerations, it is not to be wondered at that the railway master mechanic looks with distrust on all such complications as cut-off valves, starting valves, intercepting valves, etc., or that he continues to use a simple shifting link motion on account of its simplicity while generally admitting its imperfections.

We will now examine the different forms of compound locomotive more in detail to see how nearly they can be made to fulfil the requirements above outlined. The two-cylinder form is the simplest and the cheapest and involves less change from the common forms of simple locomotives than any of the others. It will therefore be naturally adopted for new engines in all cases in which its use is practicable, and also when simple locomotives are to be converted into compound.

The steam pressures which are generally used for two-cylinder compound locomotives range from 160 to 180 pounds per square inch, although pressures as low as 120 pounds have been used with good results and most

of the Russian compounds, which were converted from simple locomotives, are working with a pressure of 135 pounds. Probably the majority of simple locomotives which have been built in this country during the last two years were designed to carry pressures of 160 pounds or over, but such high pressures are of very recent introduction and 140 pounds would be nearer a general average for locomotives now in use. So that the introduction of compound locomotives is usually coupled with an increase of boiler pressure.

With the increased pressure it will generally be found that the diameter of the high-pressure cylinder is a little greater, perhaps an inch or so, than that of the cylinders of simple locomotives having the same general dimensions and for the same class of work. The low-pressure cylinder is made from 1.9 to 2.4 times as large as the high pressure, the smaller ratio being used for large engines and the larger ratio for small engines having cylinders say 16½ and 25½ inches in diameter. The most widely used ratio is about 2.1, 18 and 26 inches being common diameters. This ratio of cylinder volumes may seem small for an engine which is to use steam of 180 pounds pressure, when we consider that steam of that pressure can properly be expanded to over ten times its initial volume, but the limiting conditions in locomotives forbid the use of larger ratios. One difficulty is that a large cylinder is apt to be troublesome in various ways. If the engine is outside connected, the weight of the large cylinder and its piston and valve, tend to make the engine one-sided and hard to balance. It involves long crank pins, and may make the engine wider across the cylinders than the clearance width of the road allows, or if set in more toward the centre line, the frames and trucks must be remodeled, and the heavy piston still remains. The last mentioned difficulty has been, to a certain extent, overcome by the use of cast steel pistons. If the engine is inside connected, there is the difficulty of getting the cylinders between the frames. Then it is necessary to allow for a considerable reduction in the initial pressure in the high-pressure cylinder at early cut-offs and high speeds, and the terminal pressure in the low-pressure cylinder must be kept above the atmospheric pressure on account of the blast. In this connection in may be noted that, although the exhaust in the two-cylinder compound occurs but one-half as often as in the ordinary locomotive, that is but twice instead of four times per revolution, there is no difficulty in keeping up steam. With the same boiler and grate surface as for an ordinary locomotive of equal weight, the boiler is not required to furnish as much steam, and it is therefore not necessary to urge the fires to the same extent. It is claimed that there is, therefore, more perfect combustion, greater evaporation, and less wear and tear on the flues and sheets.

It is, of course, very desirable that the valve gear should be as simple as possible, and therefore such gears as the Stephenson shifting link are preferred, and it is further desirable that the valve gear of both cylinders should be controlled by means of one reversing lever. But if the points of cut-off are the same in both cylinders, the division of the work between the two will not be equal at different points of cut-off,

with ratios of the cylinder volumes as small as 2.1. To equalize the work with such cylinder ratios it is necessary to adjust the valve gear so that the cut-off is always earlier in the high-pressure cylinder than it is in the low-pressure. For locomotives which are to work generally in the forward gear, this is readily accomplished with sufficient accuracy, by making the hanger of the high-pressure link about $^1/_{20}$ shorter than that of the low-pressure link, so that for any position of the reversing lever in forward gear, the high-pressure link block is nearer the mid position than the low-pressure block, and the high-pressure cut-off is, therefore, the earlier of the two. In backward gear the relative positions are, of course, reversed, and this method is, therefore, not applicable to locomotives which are required to do much of their work in the backward gear. It is possible to obtain similar effects, within a limited range, by a combination of adjustments in the link motion, such as reducing the steam lap of the low-pressure valve and the angular advance of the eccentrics.

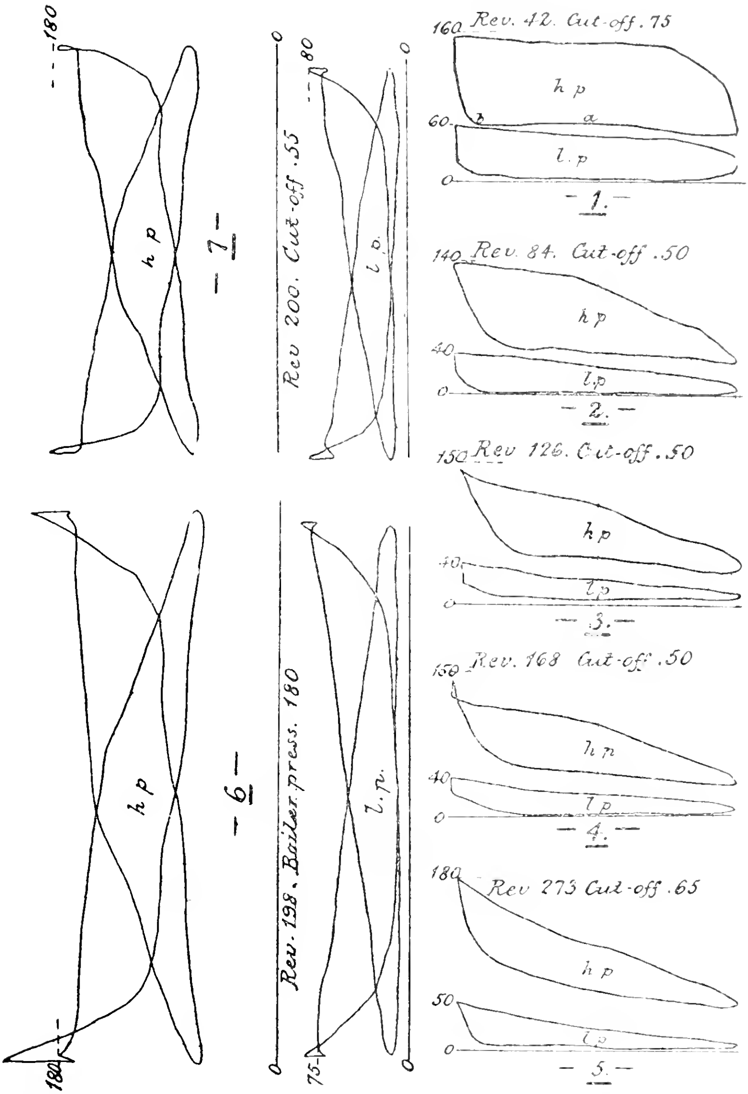
Another difficulty which requires careful study is the compression in both the high and low-pressure cylinders. With the shifting link motion, as applied to locomotives, every function of the valve is accomplished earlier as the link is moved toward mid gear. The cut-off, exhaust opening or release, and exhaust closure or compression are all earlier, and there is greater lead. The chief difficulty is with the early exhaust closure. Without going into details, this will be evident when we consider that in the simple engine the back pressure line is from 2 to 5 pounds above the atmosphere, and if the initial pressure is 160 pounds gauge, it is possible to compress the steam to about $^1/_9$ of the volume which it occupies when the exhaust closes before the initial pressure is reached. In a compound engine we may have the same initial pressure in the high-pressure cylinder, and the same back pressure in the low-pressure cylinder. But the range of compression is now divided between two cylinders.

The absolute pressure in the receiver may vary from 55 to 95 pounds, or say an average of 75 pounds, and this is, of course, the initial pressure for the low-pressure cylinder, and the back-pressure for the high-pressure cylinder. As it is never desirable to compress to a higher pressure than the initial pressure, it will be seen that with the pressures mentioned, the range within which the compression must be kept is from 75 to 175 pounds in the high-pressure cylinder, and from 18 to 75 pounds in the low-pressure cylinder. To avoid exceeding these limits with the shifting link motion, it is necessary to increase the clearance space or to cut out the inside of the valve, or both. The high pressure distribution is the more troublesome, and it is usual to find as much as $^3/_{16}$ of an inch inside clearance on the valve with a clearance volume in the cylinder and ports of from 8 to 10 per cent. of the piston displacement. Inside clearance of course involves a very early exhaust opening, but as the steam is exhausted into a closed receiver, against a considerable pressure, the loss from this source is not great. The low-pressure distribution is more easily managed, although inside clearance is not uncommon.

The question of back-pressure and compression is still further complicated by the excessive wiredrawing and resistance of the ports at high speeds.

The effects of these factors are shown by the indicator cards numbered 1, 2, 3 and 4. These are from the same engine and were taken at the speeds noted. Card No. 1 apparently agrees very well with the theoretical diagram. The portion *a. b*, of the high-pressure diagram should be very nearly horizontal, theoretically, and it will be seen that it is approximately so in card No. 1. Diagrams 2, 3, and 4 were taken at increasing speeds with the same cut-off and it will be noted that the whole back-pressure line of the high-pressure diagram assumes a continuous slope, which is still more marked in diagram 5 at higher speed and later cut-off. The apparent explanation of this is that at high speed the steam cannot get out of the high-pressure cylinder fast enough to prevent some increase of pressure, or compression, in front of the high-pressure piston, before the exhaust closes. Diagrams 6 and 7 are from the Michigan Central compound. As originally built the high-pressure valve was line-and-line inside and the low pressure valve had ⅛-inch inside lap. The lead in both cylinders was 3/32 inch, and the clearance spaces were 8½ per cent. in the high-pressure cylinder, and 4 per cent. in the low-pressure. Diagram 6 was taken with these proportions. The compression was so excessive that the engine would not run at a higher speed than 45 miles per hour. As finally adjusted, the inside lap of the low-pressure valve was cut out, the high-pressure valve was given ⅜ inch inside clearance, the lead of both was increased to 5/32 of an inch, and the high-pressure clearance was inceased to 10 per cent. Diagram 7 was taken after these changes had been made. A speed of 65 miles per hour—320 revolutions—was attained. In this connection it should be said that the volume of the receiver should be as large as practicable. Usual proportions are from 1 to 1½ times the volume of the high-pressure cylinder. With a large receiver the fluctuation in the high-pressure back-pressure will be small and the average back-pressure will be lower at high speeds. A peculiarity which is worthy of note is the admission line of the low-pressure diagrams. It will be seen that these diagrams do not differ materially in appearance from those taken from simple locomotives, and this is in spite of the fact that the supply of steam is drawn from a comparatively small space instead of from the boiler, and also in spite of the fact that at all ordinary points of cut-off there is re-admission to the low-pressure cylinder. That is, the high-pressure exhaust opens before the low-pressure steam valve closes. At very slow speeds this re-admission would cause a hump in the low-pressure admission line, but as the speed increases it apparantly serves to balance, as it were, the drop in pressure due to the expansion, and so causes the admission line to be more nearly horizontal and so more like the diagrams from ordinary locomotives.

Now as to the cylinder power of the two-cylinder compound as compared with simple locomotives. A simple locomotive carrying a boiler pressure of 150 pounds can develop at slow speed from 120 to 125 pounds mean effective pressure. Let us assume that the boiler pressure in a compound is to be 180 pounds. This must be divided between the two cylinders so that each does about the same amount of work. With a cylinder ratio of two and without allowing for any losses this means a mean effective pres-



sure of about 120 pounds in the high-pressure cylinder and 60 pounds in the low-pressure. In practice the high-pressure mean effective will not exceed 110 pounds with 180 pounds boiler pressure. So that in order to have the maximum power of the two engines the same, the high-pressure cylinder must be made larger than the cylinder of the simple locomotive in about the proportion of 125 to 110, even though the boiler pressure is increased from 150 to 180 pounds. As the speed is increased, the differ-

ence between the two engines becomes less marked and at high speed the compound is equal if not superior to the other. This does not, of course, mean that the cut-off is to be the same in both engines at the same speed, for it is not desirable to work the compound at as early cut-offs as are practicable with simple locomotives. But the compound can develop fully as high an equivalent mean effective pressure at high speed as can be obtained with the ordinary locomotive. The principal causes of this are probably, that at high speeds the compound can be worked at a later cut-off than the simple locomotive without requiring more steam than the boiler can furnish, and thereby gains the advantage of a wider port opening, less wire-drawing and a fuller steam line. So it appears that in comparison with the simple engine, the compound is, in general terms, equal or superior at high speed, but is deficient at the late cut-offs which are necessary in starting.

To remedy this defect and also to make the low-pressure cylinder generally available in starting, some form of starting gear is necessary. As has been said, the simplest form is a simple plug cock which can be operated from the cab and which admits boiler steam to the receiver. The Lindner gear is an extension of this method, the handle of the cock being connected to the usual reversing gear in such a manner that by throwing the reverse lever into its extreme position in either direction the cock is opened. When the link is hooked up, as it is, of course, soon after starting, the cock is closed by that means and remains closed for all positions of the reverse lever, except the extremes. This method simply enables the engineer to start his engine as a compound, and as has been pointed out, a comparatively large high-pressure cylinder is necessary if the compound is to be as powerful in starting as the ordinary locomotive.

Then we have the automatic intercepting valves of von Borries, Worsdell and Pitkin, all of which are the same in principle. The first is a cylindrical disk valve, the second a flap valve, and the third a piston valve, each in connection with some special features in the mechanical arrangement. The operation of these valves is, briefly: That opening the main throttle automatically closes the intercepting valve, and admits steam directly to both cylinders. When the engine starts, the high-pressure cylinder exhausts into the receiver, and after one or two strokes the receiver pressure is raised sufficiently to open the intercepting valve. The direct supply to the low pressure cylinder is thereby shut off and the engine begins to work as a compound. A locomotive fitted with one of these arrangements may be said to practically start as a simple engine, and therefore there is ample power at the start. But as compound working begins after from one-half a turn to a full turn of the driving wheels, the maximum possible pressure in the cylinders is thereafter limited as has been shown.

This form of starting gear appears to work well in practice, and the majority of two-cylinder compound locomotives are fitted with the von Borries, or Worsdell valves. The possible deficiency in power is apparently satisfactorily overcome by making the high-pressure cylinder about

one inch larger in diameter than cylinders of ordinary locomotives of the same weight and general proportions.

All forms of the Mallet starting gear which have as yet been made public, are complicated as compared with the others. Mr. Mallet has used a slide valve as a distributing valve having ports arranged so that the exhaust from the high-pressure cylinder can be directed to the receiver or to the exhaust nozzle as desired, while at the same time the direct steam supply to the low-pressure cylinder is closed or opened. Another form consists of a small slide valve for a starting valve in connection with a sort of double poppet valve as a distributing valve. The Mallet system has the advantage of the others in that a smaller high-pressure cylinder can be used without any danger of making the locomotive deficient in starting power. It therefore makes it possible to convert most ordinary locomotives into compounds by simply putting on a new and larger cylinder for the low-pressure.

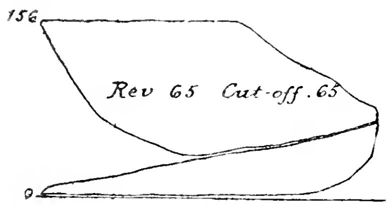
Turning now to three-cylinder compound locomotives, it is apparent that there are two possible arrangements, *viz:* one high-pressure and two low-pressure cylinders, or two high-pressure cylinders and one low-pressure. The latter is the form of the Webb compound and a brief summary of some of its peculiarities may be interesting. There is no provision for admitting boiler steam to the low-pressure cylinder in starting. But there are no coupling-rods and full boiler pressure on the high-pressure pistons will generally be enough to slip the corresponding pair of driving wheels. When this occurs the high-pressure cylinders exhaust into the receiver and the low-pressure cylinder is thus supplied with steam. If the low pressure crank is not at or very near a dead point there is no difficulty in starting, but if it happens to be so situated, the high-pressure cylinders are alone available. As these cylinders are but 14″ in diameter, the locomotive would then be very deficient in starting power. The starting power of the engine therefore depends largely upon the skill of the engineer, who must see that he does not stop his engine with the low-pressure crank on the centre. The low-pressure cylinder in the Webb locomotives is usually 30″ in diameter, is placed directly beneath the smoke box and is connected to the forward driving axle, the crank being in the middle of its length.

As has been mentioned, a three-cylinder locomotive of the other form having one high-pressure and two low-pressure cylinders has been built by the Northern Railway of France. The cylinders are 17″ and 19.7″ in diameter, by 27.6″ stroke. The low-pressure cylinders are placed outside as usual, the high-pressure cylinder is inside connected, and all of the driving axles are coupled. In this form of locomotive ample starting power can be secured by simply admitting steam of about one-half the boiler pressure to the receiver.

A peculiarity of three-cylinder compound locomotives is the possible division of the work between the cylinders. With the ratio of cylinder volumes which are practicable for locomotives the tendency is for the low-pressure cylinder to do more than one-half of the total work. In fact, it cannot generally be made to do less than one-half. So we find, that the

work done in the single low-pressure cylinder of the Webb engine, is equal to, if not greater, than that done in both high-pressure cylinders. As the low-pressure pair of driving wheels is independent of the pair driven by tbe high-pressure cylinders, this is as it should be, and further there would be very little advantage in coupling the driving wheels on this type of locomotive.

For the same reasons it is possible to divide the work very evenly between the three cylinders of the other type of three-cylinder compound, and it is not possible to arrange it so that the single high-pressure cylinder will do as much as one-half of the work. Therefore, it is in this case highly advisable to use coupling rods.*



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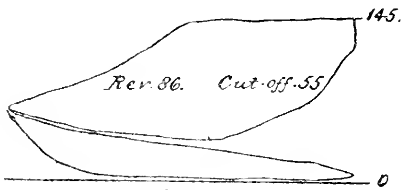

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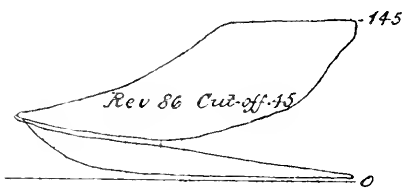

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Four-cylinder receiver engines do not show any special peculiarities. They may, in fact, be regarded as two two-cylinder engines put together. In those built by the Paris, Lyons & Mediterranean Railway, the high pressure cylinders are inside connected and the low-pressure cylinders are outside connected. These locomotives are necessarily very complicated, as the valve gear and reciprocating parts are quadrupled. On the other hand, they are very powerful, there is no difficulty in starting, and they can be very readily balanced. A tandem four-cylinder compound loco-

* This locomotive is now (Aug., 189[illegible]) at work in passenger service between Baltimore and Philadelphia.

motive was designed by Mr. H. D. Dunbar in 1883 and was tried on the Boston & Albany Railroad. This engine was reconverted into a simple locomotive as it "gave no economy." No details as to tests upon which the cause of the failure could possibly be determined have been made public. A tandem engine built by the Northern Railway of France has given very satisfactory results. The four-cylinder compound built by the Baldwin Locomotive Works is identical in principle with the tandem engines. This engine did the work for which it was designed with economy, but the steam distribution was not perfectly satisfactory and at last accounts the engine was in the Baldwin Works having new valves put in.

In engines such as these in which the high and low-pressure pistons move simultaneously, or which are sometimes called continuous expansion engines, there is no receiver and all dead space between the pistons is disadvantageous. The indicator cards from this form of compound engine are quite different from those for receiver engines, as will be seen by a reference to the diagrams numbered 8, 9 and 10, which are from the French Tandem engine. In locomotives of this type, the adjustment of the valves is still more difficult than in the receiver engines. When the pistons are concentric, as in the tandem arrangement, the division of work between the cylinders is comparatively unimportant. The problem of starting is not difficult since if the area of the low pressure piston is equal to the piston area of the simple engine, a valve for admitting boiler steam between the pistons is all that is necessary.

Comparing the different forms of compound locomotives we see that the two cylinder type is by far the simplest, and it would therefore be the natural choice in all cases excepting those in which the necessary great size of the cylinders—for a locomotive—forbids its adoption. With the three-cylinder type it is practicable either to use two small low-pressure cylinders instead of one large one, or to do away with some coupling rods. It is also possible to employ a greater ratio of cylinders and, therefore, to more fully realize the expansive power of high pressure steam. The distribution of the weight may be better than in the two-cylinder type, and a very uniform turning moment can be obtained. To offset these possible advantages, there is the increased complication, and therefore the increased first cost and expense of maintenance.

The four-cylinder receiver type has some of the advantages mentioned for the three-cylinder form, together with the possibility of making a very perfectly balanced locomotive. It is, of course, the most complicated of all the possible arrangements which have been mentioned. The tandem and Baldwin forms are not much more complicated than the two-cylinder type, and the use of large cylinders is avoided, but the weight of reciprocating parts is increased, and when a leading truck is used there is an increase in dead weight.

Having noted the different forms of compound locomotives which are in use, and shown some of the principal difficulties which must be overcome in their design, we may now properly take up the question. Why should compound locomotives of any form be used? The answer to this is: Simply for economy. It is not necessary to attempt to explain in

detail to members of an engineers' club why a compound engine is in general more economical than a simple engine. We know very well that when properly designed for the work to be done, that it is so. And that for many classes of work, knowing the probable saving in coal per horse power, a simple arithmetical calculation involving first cost, interest, etc., will determine whether or not a compound engine should be used.

The principal reasons why the compound locomotive should be more economical than the simple locomotive are apparently that, for a given mean effective pressure, the cut-off is later, the steam distribution is therefore better, we would expect less condensation as the difference between the initial and final temperature of the steam in each cylinder is reduced, and by placing the receiver in the smoke box the steam is more or less dried out on its way to the low-pressure cylinder. Then, as more work is obtained from each pound of steam, the boiler is more moderately worked, the steam should be drier and the rate of evaporation per pound of fuel should be higher.

Compound locomotives have made just about such a record during their short existence as we would naturally expect. When carefully designed for the work which is required of them they have given very satisfactory results. The saving of fuel over that used by ordinary locomotives doing the same work ranges from 13 to 24 per cent. The general average of a large number of tests, giving each test a weight proportional to the time it occupied, is 18½ per cent. for engines using coal as fuel. It is interesting to note that the highest reported percentage of saving is for engines in which the same boiler pressure, 176.4 pounds, was used. Mr. Urquhart has found for petroleum burning locomotives in Russia that a saving of from 14¾ to 25½ per cent. was obtained by converting ordinary locomotives into compounds, the boiler pressure of all engines being 135 pounds. The last percentage, 25.5, is, it seems to me, higher than can be reasonably accounted for by simply compounding a locomotive at 135 pounds boiler pressure. The 18½ per cent. is, however, the average of tests of 60 compound locomotives in various parts of the world, the average length of the tests being about five months.

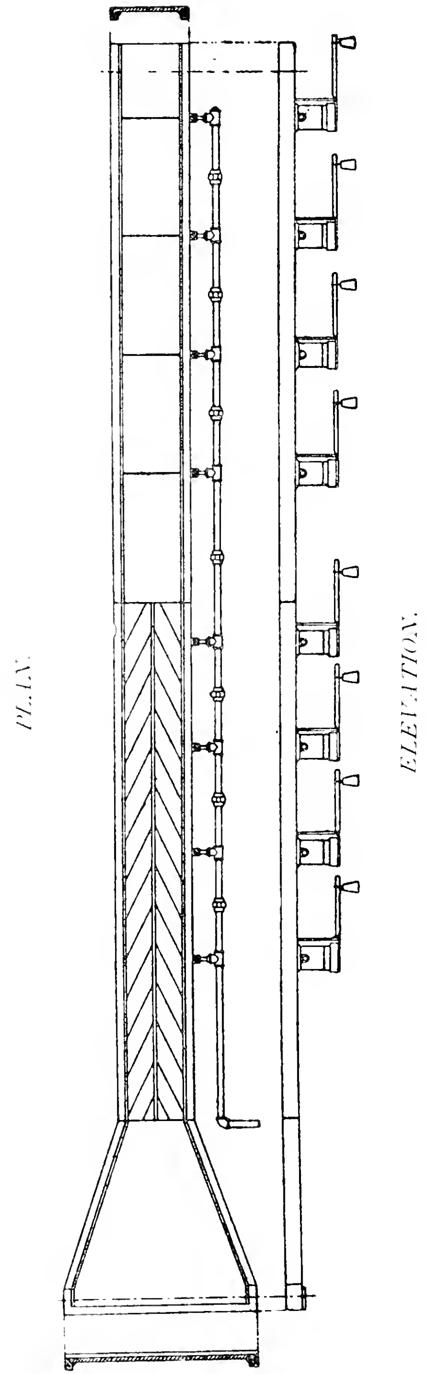
On the basis of an annual mileage for an engine of 30,000 miles, and 30 miles per ton of coal, the total coal consumption per engine per annum is 1,000 tons. A saving of 18½ per cent. is 185 tons per engine per annum which at $2 per ton costs $370. This is a low estimate, but it would probably be generally admitted that such a saving is worth striving for. The extra first cost of a two-cylinder compound over that of an ordinary locomotive is slight and the cost of converting most forms of simple locomotives will not be great. In either case it is probable that a year's saving in coal will more than meet the additional expense. It has been said that building a compound locomotive for the sake of a possible saving of from 15 to 20 per cent in fuel is a doubtful experiment, inasmuch as a change in engineers on simple locomotives may make a difference of 25 per cent. But a great advantage of the compound system is that if the engine is properly designed for the work it has to perform, its coal saving capabilities are to a great extent independent of the engine runner. If he is care-

less with one engine he will be so with another, but it is possible for him to waste more fuel with the simple engine than with the compound, and if both are handled with the same degree of care, the compound must use less fuel than the other.

It has been shown that the range of power of a compound engine is necessarily more limited than that of the simple engine, and it follows directly from this that the compound locomotive must be carefully designed for the work which it is expected to do, if the best results are to be obtained. The first requisite in starting the design of a compound locomotive is, then, exact data as to the work to be done by it. With this information an engine can be built which will have an ample range of power for the service required, and which will be comparatively economical. This point is dwelt upon because there is apparently a sort of popular idea that if a compound locomotive is good anywhere it should be good everywhere and conversely if it fails anywhere it is therefore no good at all. This idea possibly originated in the old custom of using old locomotives which were too decrepit for further work on the road for switching engines. It has been discovered that this was apt to be poor economy and switching engines are now generally designed for that special purpose. In the same way heavy freight engines and express passenger engines are no longer supposed to be properly interchangeable. Compound locomotives must be regarded in the same way, and simply designed for the work they are to do.

It is by no means to be inferred that all locomotives should properly be compounds, any more than that all stationary engines should be compound. For switching and suburban traffic, where the stops are very frequent, their utility is doubtful. But for express passenger service and for heavy freight work they can, in my opinion, unquestionably be used with decided advantage. This opinion has not been hastily formed but is the result of a careful study of the question covering several years.

There is now reason to believe that within a few years a large number of compound locomotives will be in operation in the United States. The idea is new, and a good deal of experimenting must be done before the best design for each class of service can be thoroughly established. Errors have already been made which could have been avoided by study on the part of the designers and some failures are naturally to be expected. But the rapid increase in the number of compound locomotives during the past three years indicates that they have come to stay—as long as we use steam locomotives.



THE PEMBERTON CONCENTRATOR

APPROXIMATE SCALE ¼ INCH = 1 FOOT.

THE PEMBERTON CONCENTRATOR.

By Frank Nicholson, Member Engineers' Club of St. Louis.

[Read April 2, 1890.]

During the past twenty years new devices for the concentration of ores have been patented. While many of these have got but little further than the Patent Office, still the number that have been given a fair, practical test is not inconsiderable. No entirely satisfactory machine has yet been devised for handling the tails from stampmills, the claims of sundry manufacturers to the contrary notwithstanding.

In fact, it has come to be a common saying among mill-men, that the ore which will not pay without the aid of concentrators will not pay at all, and I must add that my own experience—especially in gold-milling—would seem to verify this pessimistic statement.

Probably the most serious difficulty in the way of success in concentrating tailings is the almost universal lack of proper sizing facilities. Concentration without previous sizing has generally been found to result in failure, more or less complete, according to the amount of variation in the size of the particles treated. A fragment of pyrite will sink in a column of water faster than a fragment of quartz, *provided* the two fragments are of the same size and shape: but a large particle of quartz may beat a smaller particle of pyrite in their race to the bottom.

Thus our concentrates usually contain worthless coarse sand: while slimes of value reach the tailings pond.

Perhaps the most successful concentrators for treating tailings, have been those of which the Frue Vanner is the type; yet the mills are not infrequent where these have been abandoned in disgust.

It is a fact worth chronicling that at Vulture, Arizona, the Cornish Buddle has been selected after months of experimental work, to treat the 700,000 tons of tailings from the Vulture mill. These tailing are estimated to contain $1.75 in gold per ton. Experiment has demonstrated the fact that the Cornish Buddle will save 65 per cent. of the value at a cost for treatment not exceeding fifty cents per ton. The net profit, on the above basis, will be 63¾ cents per ton or for the whole amount $446,-250—not an insignificant sum. With proper sizing, this historic machine, dating back to a past century, can accomplish even better results. The problem of thorough and economical concentration has not yet been solved.

The machine to which I now wish to call your attention is so new and

comparatively untried that I should be rash indeed to predict for it immunity from all the many disadvantages that seem to be inseparable from the many types now in use.

The Pemberton concentrator is chiefly remarkable for its simplicity. There are no pulleys, belts, gears, or the thousand-and-one parts that, in the ordinary concentrator, seem to vie with one another in getting out of order and discouraging the long-suffering mill-man. Neither is any H. P. required, hence it can be operated at small cost.

The principle involved is the usual one. Water is the medium employed and the results depend upon the difference in specific gravity of the valuable and waste particles. Sizing is here as essential to good work as in other types.

A glance at the drawing will explain the construction. So simple indeed, is the machine, that I have not deemed it necessary to letter the drawing so as to refer to the parts in detail. Plan and elevation are given with two sections.

The machine consists of a sluice with small openings at intervals along the bottom, leading into boxes attached underneath. Water is admitted to these boxes under such head as may be desirable, being regulated at will by the stop-cocks shown on the drawing.

The bottom of each of the eight boxes consists of a 2″ piece of wood, to which is fastened a strip of iron, and all so hinges as to form a lever of the first class. The apron and the first section of the sluice are covered with copper plates. The plates on the apron are laid flat and secured by countersunk screws to the inch boards of which the sluice is constructed. The plates on the sluice proper are so put down as to form riffles tending to divert the stream of pulp always towards the central groove, which is ¾″ wide and ½″ deep.

The apertures found at intervals along this grove are ¾″ long and $^1/_{16}$″ in width. The length of the first section is 11′. In the second section no plates are used. The boxes are 4″ × 19″ in section 6½″ deep; while the apertures are placed at right angles to the flow of tailings are $^1/_{16}$″ wide and extend clear across the sluice.

To operate this concentrator it should be set with but little fall—just enough to prevent the tailings from banking in the sluice. The boxes are filled about two-thirds full of concentrates in order to keep the water from running out at the bottom. Then move the adjustable weights far enough back to keep the traps closed and turn on the water.

Now balance the lever arms nicely by means of the eight sliding weights until they will just keep the traps closed. As the concentrates accumulate in the boxes the traps are forced open and the contents gradually escape. If the concentrates escape too rapidly, the load being taken off the trap, it closes automatically. Of course, suitable bins are provided for the reception of the escaping concentrates.

All particles entering the boxes must do so against the upward pressure of the water through the apertures. Thus we have applied on a commercial scale, the method used in the physical laboratory to determine the laws of the concentration of ores.

The concentrates saved are found to be graded, the richest and cleanest being caught nearest the apron, while towards the tail of the sluice they become progressively poorer. Just what this machine will accomplish, it is yet too early to predict with any certainty; but its extreme simplicity would seem to warrant one in the conclusion that it will have ample opportunity to demonstrate its possibilities. Probably its greatest drawback —at least as far as its use in the arid portions of the West is concerned— is the large amount of water required for its operation. This could be overcome in some measure by settling and using over and over again. I may be able in a subsequent paper to give some figures of interest taken from the records of actual work of this machine.

THE EIFFEL TOWER FROM FOUNDATION TO LANTERN.

BY AMBROSE SWASEY, MEMBER OF THE CIVIL ENGINEERS CLUB OF CLEVELAND.

[Read April 8, 1890.]

The great feature of the Paris Exposition around which everything centered, was the Eiffel Tower. It has been called a huge flag-staff, also a gigantic candle-stick, thus serving the night as well as the day. So much has been written and published about this structure, that not only its great height, but its peculiar shape has become familiar to the whole world, and whether traveling through the streets of Paris, New York, London or Rome, one constantly beheld the pictures and models of this strange looking shaft. It is therefore very late to give any new information concerning this great work, to a body of American Engineers, yet if I can succeed in refreshing your memory about some of the details of its construction, I shall feel satisfied; for when we reflect upon such great engineering works, we can but have more respect for man, and more confidence in his power to deal with the forces of nature.

I shall never forget how thousands of others as well as myself, upon entering the gates of the Exposition, and for the first time were brought face to face with the tower, simply stood still and looked,—not a word was spoken, and it seemed to be a time when even whispering was entirely out of place. This was not only the case at first, but I found myself often gazing at it, and wondering how man, with all his knowledge, could ever have the

courage to undertake such a work. It was a grand sight I assure you, to stand upon its high balconies and view the city, with its beautiful domes and spires, and the exhibition grounds below thronged with distorted looking people moving about among the odd shaped buildings erected by the different countries and nations all over the world. Yet it was a much grander sight to stand upon the ground and follow the iron lines of the tower up and up, until almost out of sight in the blue sky could be seen the national flag floating from the top.

Mr. Gustave Eiffel was born in Dijon, France, in 1832, and looks to be scarcely 50 years of age. He commenced his professional career quite young, and has been engaged in many important engineering works. He has made a specialty of constructing bridges with long spans, without scaffolding, one of the most important being the Garabit Viaduct with a single span of 545 feet built piece by piece from each side over a rushing torrent, until united at the center, it formed an arch 400 feet above the water. Another branch of engineering work of less importance, but one which shows his originality, was the construction of the dome for the Nice Observatory, 75 feet in diameter, weighing 100 tons. This dome he made to float in a circular trough filled with water, thus overcoming friction, which allowed the dome to be easily revolved. The great locks of the Panama Canal were designed by him, but as we all know, up to the present time have never been constructed. In our own country we have still another example of his work, combining the Coppersmiths' skill with that of the Engineers' in the construction of Bartholdi's Statue of Liberty.

In the Exposition grounds was erected a very handsome building surmounted by a model of the Nice Observatory dome, 20 feet in diameter. This building contained large sized models, maps, charts and drawings of Mr. Eiffel's many and varied engineering works, which was a very valuable exhibit to those interested in such subjects, and showed that he was truly a busy man, and a great engineer.

During the visit of the American Engineers in Paris last summer, Mr. Eiffel invited a party of about 20 to visit the tower and inspect it in detail more than was possible by simply going to the top and returning. Mr. Salle, his son-in-law, who had charge of its construction and was thoroughly familiar with every detail, together with several members of the French Society of Civil Engineers and the representatives of the three systems of the Hydraulic Elevators used in the tower, met the party at about eight o'clock in the morning and devoted the remainder of the forenoon in explaining the details of its construction. It was my good fortune to be among the number, and I assure you that it was a great treat to us all to have the privilege of seeing the many interesting things in the tower from the bottom to the top. The four foundations which support the tower were commenced in January, 1887, and completed in June of the same year. These form a square of about 330 feet, and each foundation is composed of four piers, the centers of which form a square of about 50 feet. Fig. 1 and 2. These piers extend below the surface of the ground according to the various depths of the underlying strata of sand. The piers for the foundations farthest from the river Seine extend 25 feet below the sur-

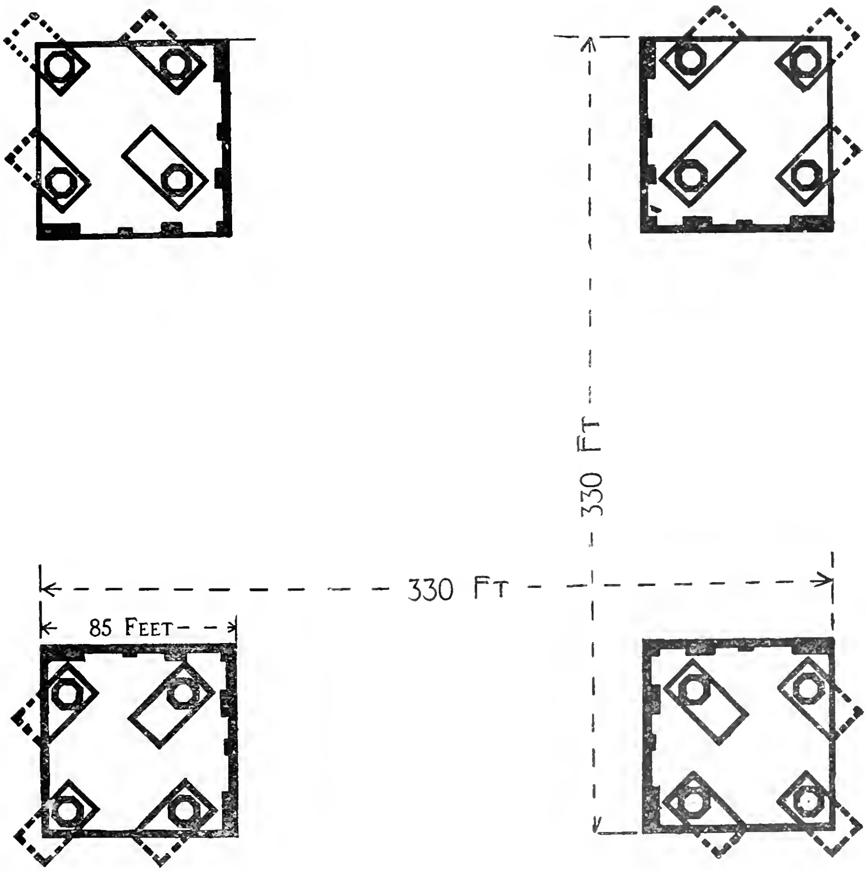


Fig. 1.

PLAN OF THE FOUR FOUNDATIONS.

face, and rest upon a bed of concrete 8 feet thick, 32 feet long and 19 feet wide. For the foundations nearest and parallel with the river, it was found necessary to construct the piers on caissons which were sunk about 40 feet below the surface, a separate caisson being constructed for each pier, making in all for the four foundations, 16 piers built up independently.

The total weight upon the masonry of each pier is about three tons per square foot, the capstones having a crushing strength of 16,000 pounds per square inch, while the whole load is but a little more than 400 pounds per square inch. Two bolts of four inches diameter extend 20 feet into the masonry, and are anchored to iron plates 8 inches thick. These bolts are 5 feet apart, and serve to hold the bases of the iron columns firmly against the capstones of the piers, which proved very serviceable during the erection of the tower. Fig. 3. Around the piers is built a wall 85 feet square, and about 30 feet high, that forms the base upon which apparently the great columns of the tower rest; but in reality this base is only a shell enclosing the base of the column, and has no part in its support, but its splendid proportions and finely cut moldings make a very handsome foundation, from which the iron columns spring, giving the whole structure a grand appearance. If the tower had been built in this country the piers would probably have been brought a short distance above the ground, to receive the iron columns, and the ornamental base would have been left off.

The Engineers while in Europe last summer especially noticed the ornamentation, or, we may call it the architectural features of engineering works, and the attention paid to symmetry and beauty as well as utility. In many cases they were more expensive, yet in a large proportion it was apparently just as cheap to make correct and easy lines as ugly ones. Already in this country. more attention is given to the beautifying of engineering works, and we have some notable examples which are a great credit to American Engineers, yet if all engineers would study to design with that end in view as well as strength and fitness, we should see a great deal more done in that direction.

The tower is constructed entirely of iron, and weighs 7500 tons. At first it appears to be composed of several independent sections placed one above the other. The first section from the ground to the floor, 180 feet, especially gives it this appearance. The massive arches that spring from the ground seeming to be sufficiently strong to carry the upper portion of tower; from the first to the second floor is another section, the third section being the shaft which is surmounted by the lantern. But a closer inspection shows that the tower is built of four latticed columns that spring from four foundations, the corners of each column resting upon the four piers. These columns curve toward each other until they unite and form a single column, 906 feet from the ground, 33 feet square, and what appears to be different sections are simply belts or girders which tie the great columns together, and upon which rest the different platforms, while the great arches of the lower section, which measure in the clear 130 feet from the ground, are purely for architectural effect and have nothing to do in supporting the weight of the tower.

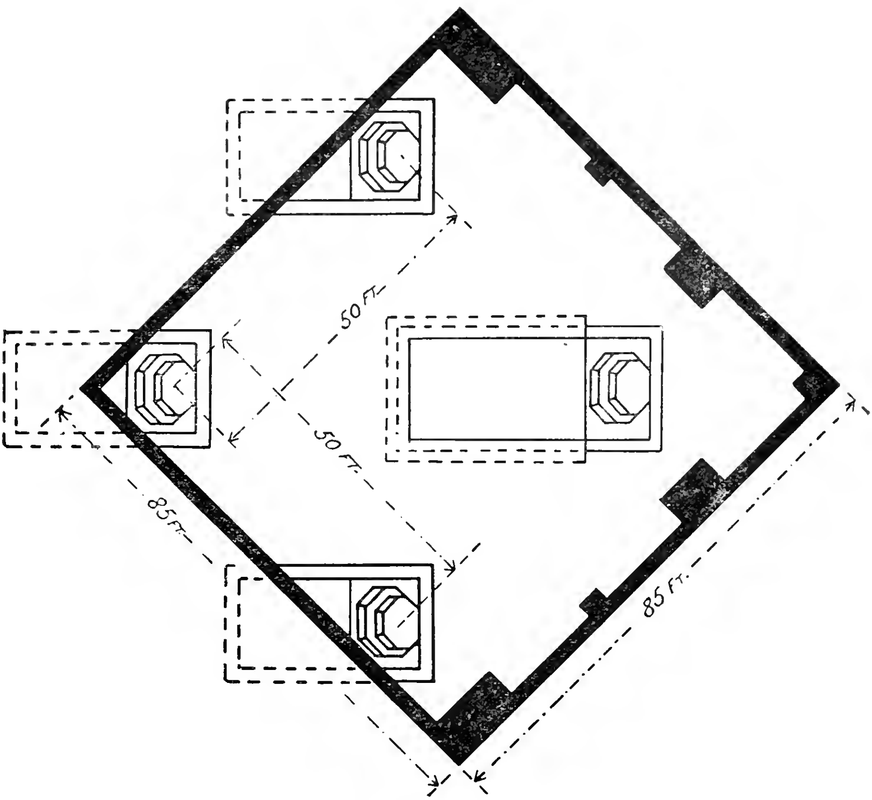


FIG. 2.

ENLARGED PLAN OF ONE FOUNDATION.

The first landing as before stated, is 180 feet from the ground and rests upon girders 24 feet deep, attached to the main columns. This landing has a floor space of 38,000 square feet, and contains four restaurants, each 105 feet long, called the French, Russian, Flemish and Anglo-American restaurants.

I suppose the reason why they did not have a German restaurant or beer saloon was because the tower had but four sides and the Germans did not feel like crowding out any of the others just at present. There were four pavilions 50 feet square, and galleries made inside and outside, the outside gallery being 8 feet and 6 inches wide and if extended, would be about 1000 feet long. In addition to this the four elevators necessary for so many passengers, take up a great deal of room. This floor does not cover the entire section of the tower formed by the four columns at this point. In the center is left an opening 100 feet square so that the central part of the column is left uncovered until the second landing is reached.

The party of American Engineers were invited by Mr. Eiffel to breakfast at the American Restaurant of the tower, (by the way the breakfast was at 12 o'clock noon). In addition to the American party which numbered about 300, many of the prominent officials of Paris and French Engineers were present, numbering in all about 500. These were all seated at one time in this single restaurant, and as this occupied about one-fourth of the floor space devoted to that purpose, you can get some idea of the enormous dining hall 180 feet above the ground. The second landing is 380 feet high and contains 15,000 square feet of floor space. It is surrounded by a covered gallery 8 feet and 6 inches wide.

Three elevators occupy a large portion of this floor, two of which bring passengers from below, the third taking them to the top. Very little time is usually spent by visitors here, as the change is made from one elevator to the other and the passengers are anxious to get to the top of the tower as soon as possible.

The third landing is practically located on the top of the tower 906 feet high, and although the column at this point is but 33 feet square a gallery supported by brackets is built outside of the main column, which gives a floor space 53 feet square. This construction adds greatly to the beauty of the tower from the outside. This floor is the highest point reached by the elevators, and as high as the public are admitted. It was found necessary to protect this gallery by glass, which somewhat obstructs the view. Here a great business is carried on in the sale of models of the tower, photographs, etc., and as is usually the case one has to pay well for the extra height.

Above this floor rises the campanile, which is surmounted by the lantern, the distance to the top being about 80 feet. From the diagonal corners of this gallery spring four latticed girders, uniting and forming an arch 54 feet above, which supports a gallery 19 feet in diameter. This is reached by a staircase from the third floor, the first landing above forming the roof of the gallery below. Upon this landing is mounted a good sized cannon, which is fired at 6 o'clock every evening and is the signal to shut down the great engines of the machinery hall.

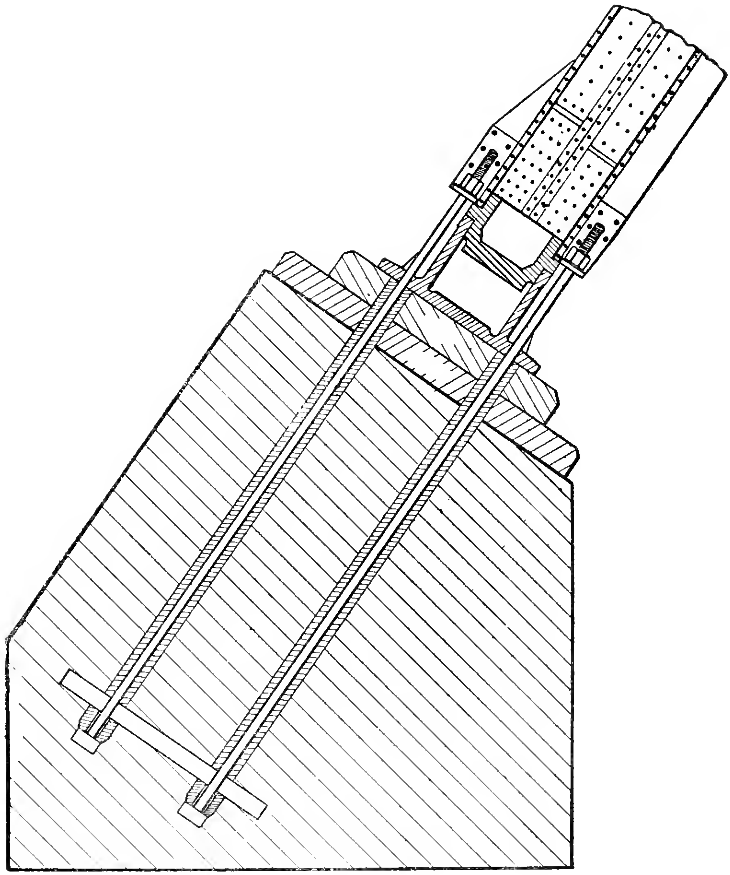


FIG. 3.

DETAIL OF ANCHORAGE.

From this landing a spiral staircase extends to the gallery above the arched girders, on which the famous Mangin projectors or electric search lights are placed. They are mounted upon trucks which run upon a circular track extending around the tower and so arranged that a powerful beam of light can be thrown in any direction about the city or lowered to illuminate the exhibition grounds below. Above this there is still another gallery which is reached by entering a column just large enough in diameter for one person, and by ascending a ladder within, the lantern gallery is reached, a distance of about 65 feet from the third landing or about 970 feet above the ground. This is the topmost gallery of the tower and the highest standing place with the exception of a small platform which surmounts the lantern, which is 6 feet in diameter and exactly 300 meters or 984 feet above the ground. From the center rises a flag-staff, at the top of which the French flag floats. This platform is equipped with meteorological instruments and is used exclusively for that purpose, no one being admitted there except the person having charge of the instruments.

When standing on the lantern gallery we are brought close to the great light-house of the tower, which is similar to the light-houses used in this country with the exception that an arc light is used instead of oil. The stability of the tower was especially noticeable at this gallery, there being no perceptible vibration. As I stood there at the top of the highest engineering work in the world with an unobstructed view for miles around, the thought came to me that although man may have the ambition to devise, the courage to attempt and the skill to construct a tower of such a height or even higher, which will no doubt prove of great value to the world in many ways, yet, as the mechanician has been able to construct instruments so accurately that it is difficult for man to detect their errors, so the engineer has been able to construct a tower so high that the objects viewed from the top are so far distant that the human eye can not well define them.

If our eyes had the light gathering power of a telescope of several inches aperture, then we could see distinctly every detail from the very top, but as all the light has to come to us through the pupil of our eye, $^1/_5$ of an inch in diameter, the distance is too great and which ever way we look there is lacking that desirable and essential quality of a good picture, distinct details in the foreground.

It has often been remarked that the finest view of Paris is from the top of the towers of the famous Notre Dame Cathedral, which are of the same height as the first landing of the tower, and I noticed that on this floor the people seemed to get the most satisfactory view of the city and of the beautiful buildings, fountains and statuary in the grounds below.

There are two methods of ascending the tower, one by stairs and the other by elevators. From the ground to the first floor very easy stairways with landings are placed in the east and west columns, one being for ascending and one for descending. From the first to the second floors there are spiral staircases in each of the four columns, two for ascending and two for descending, with landings at every 35 feet. From the second to the third floor a circular staircase is built, but it is only used by the em-

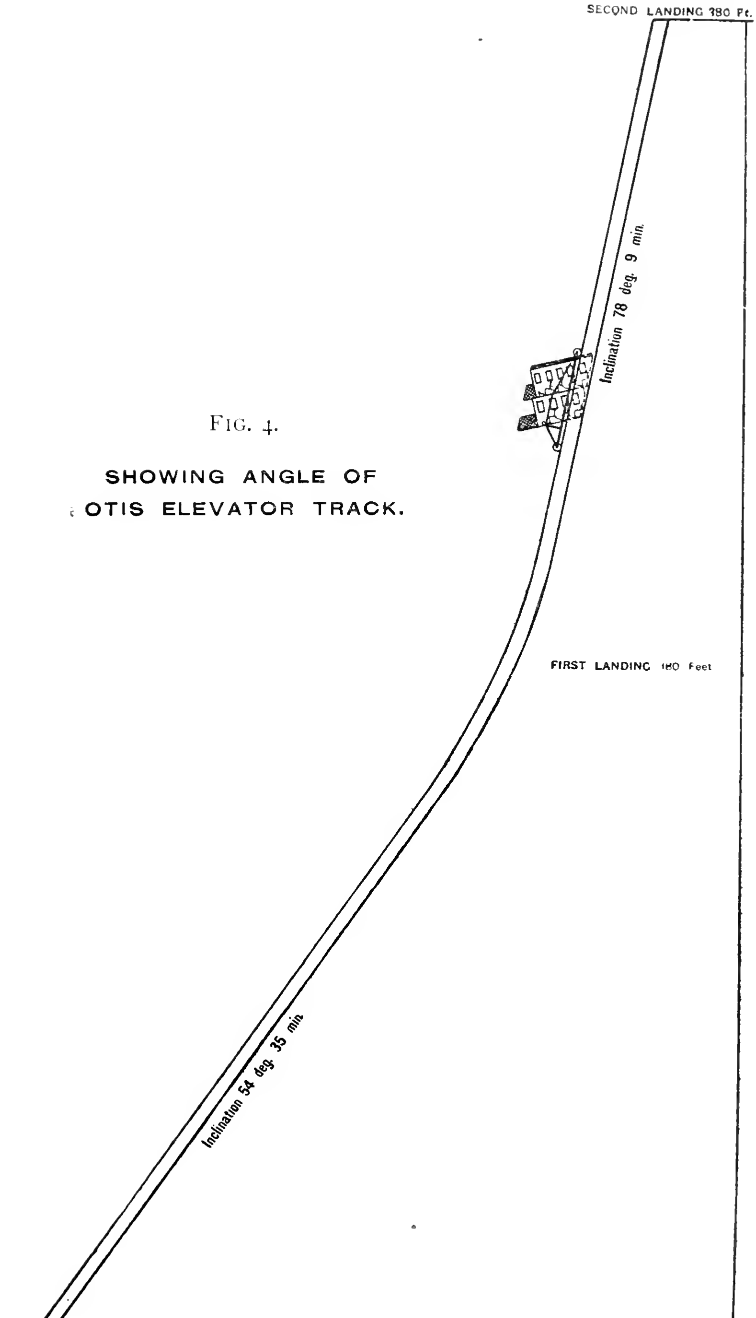


FIG. 4.

SHOWING ANGLE OF OTIS ELEVATOR TRACK.

ployes of the tower. From the third floor to the lantern there are stairways as I have before described.

The second method of elevators or lifts, as they call them in Europe, is certainly very interesting. From the ground there are elevators in each of the four columns leading to the first landing. Two of these are of the Otis American system and two of the Roux system. From the first to the second floor the Otis elevators, that run from the ground to the first floor, are extended, taking passengers the whole distance from the ground to the second landing. From the second to the third floor the Edoux system was adopted. The Otis system we are quite familiar with, but there were some very difficult problems to solve on account of the variations in the angles, Fig. 4, from the ground to the second floor, caused by the curvature of the columns, the changes in the angles being about 20 degrees. The cage is two stories high and is held by four wire ropes $^{79}/_{100}$ inches in diameter. There are also two cables $^{9}/_{10}$ inches in diameter attached to the counterbalance carriage, which runs on separate tracks beneath that on which the cage runs. A very excellent system of safety brakes was attached to the carriage, more attention being paid to this element of safety than in the other systems. They were subjected to severe tests, the cables being cut several times, but in every instance the brakes proved to be very efficient.

These elevators move 400 feet per minute, one foot movement of the piston being equal to 12 feet of the cage. The cages were designed to carry 50 persons, but 40 was the usual number taken. It takes about one minute to reach the second landing from the ground, a distance of 380 feet. These elevators move very smoothly, and the Otis Company deserve great credit for the manner in which they have worked out the mechanical details of such a difficult problem.

The Roux elevators, Fig. 5, which take passengers from the ground to the first floor are of a very peculiar construction and consist essentially of two long endless chains or linked belts revolved from below by large sprocket wheels 12¾ feet in diameter and running over idler wheels 11½ feet in diameter, located a little above the first floor.

The links of these great chains are 3¼ feet long and 1¾ inches in diameter. At the center of each joint there are two pulleys that run in guides attached to the curved columns of the tower, the whole length of the chain being guided by these tracks both going and returning. There are two of these endless chains for each elevator, one attached to each side of the cage. When the large sprocket wheel revolves, the cage is carried up by means of these chains, the motion being reversed for the descent of the cage. The sprocket wheel shaft is made to revolve by means of a plunger 41 inches in diameter, having 16½ foot stroke working in a hydraulic cylinder. On the end of this plunger are two wheels 63 inches in diameter, over which pass two chains or link belts. These chains are fastened to the stationary cylinder and then passing over the pullies on the end of the plunger, return and make a one-half turn round a small sprocket wheel 23 inches in diameter which is keyed to the large sprocket wheel shaft. The water pressure moving the piston outward, causes the

shaft to revolve, carrying the cage up, releasing the water in cylinder, the cage returns by gravity.

A separate cylinder is used for each chain, thereby making the whole system duplicate, so that should any of the mechanism connected with one

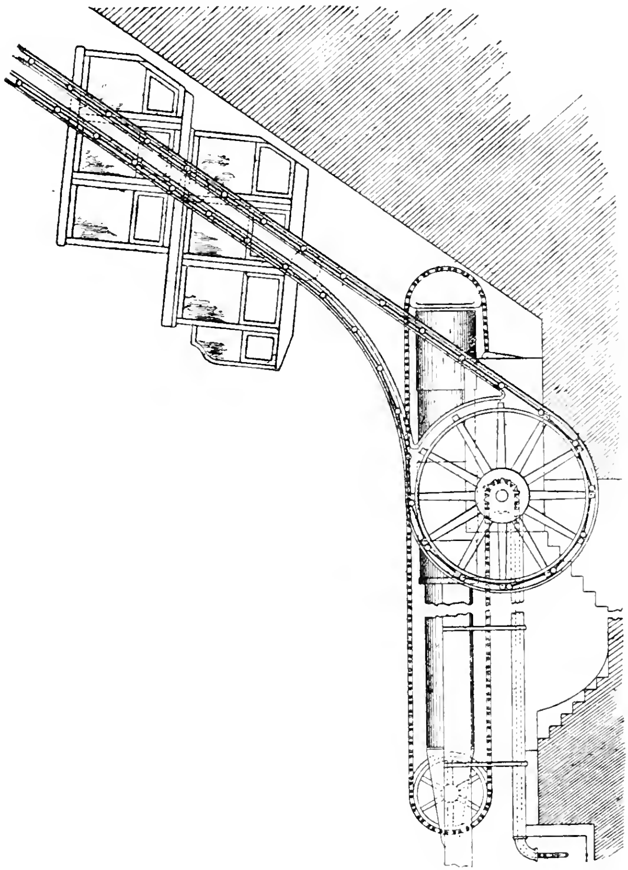


FIG. 5.

ROUX ELEVATOR.

side of the cage break, the other is sufficiently strong to hold up the weight, besides the whole arrangement is made excessively strong, dependence being placed upon these two elements for safety. The carriage is two stories high as in the Otis and will take at one trip 100 persons, 40

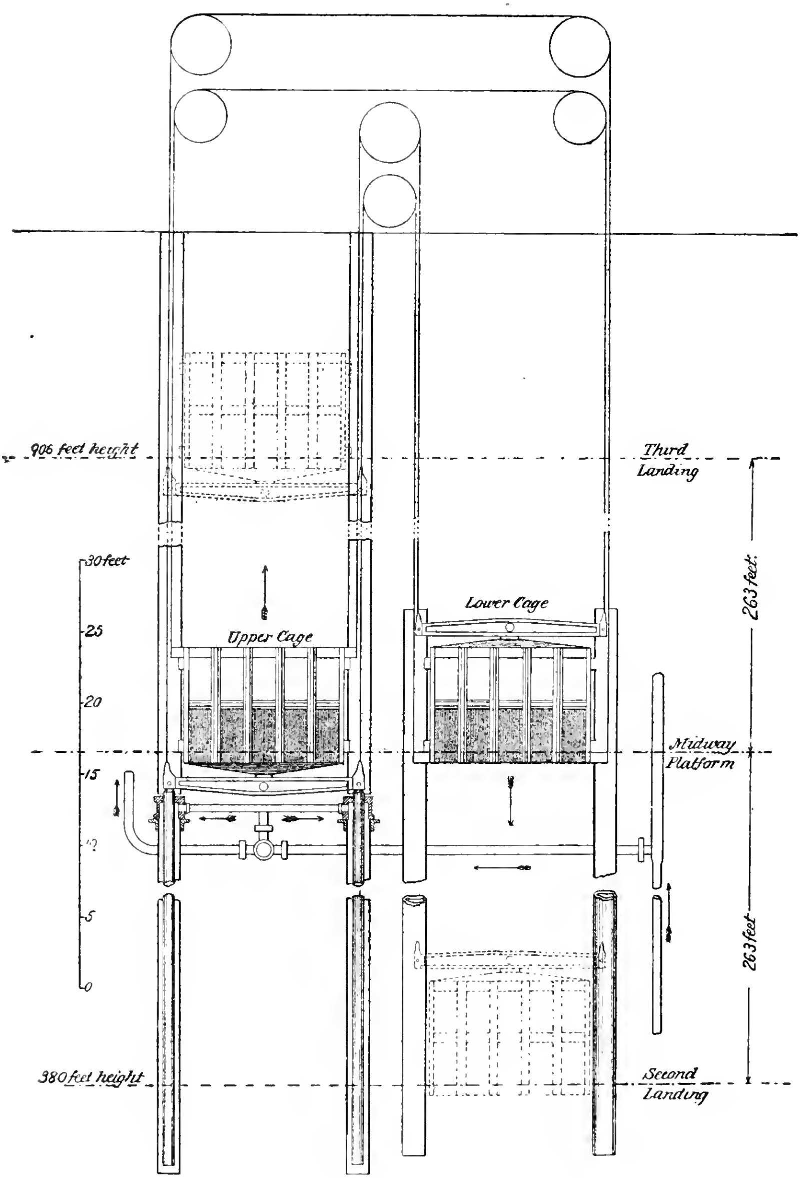


FIG. 6.

EDOUX ELEVATOR.

sitting and 60 standing. It travels 200 feet per minute and makes twelve trips an hour. The motion is not controlled from the cage as is the custom in this country, but entirely from below, so that when the cage is at the first story, the attendant in charge blows a small Swiss horn unmercifully as a signal for the man below to turn the valve and start the cage downward.

These elevators have given excellent satisfaction but are extremely noisy. They were invented especially for this purpose and I see no reason why others should be made like them, unless a duplicate tower is to be built. The Edoux system of elevators, Fig. 6, manufactured in Paris, are used quite extensively on the continent and the success which attend those placed in the towers of the Trocadero in the Exposition in 1878 led Mr. Eiffel to adopt the same system, between the second and third landings, a distance of 526 feet. In this case there are two cages which counterbalance each other, suspended by wire cables running over sheaves attached to the tower a short distance above the third floor. These cables are composed of several strands woven together, making a wire belt. Two of these are attached to each side of the cages, making four in all, any one of which is sufficiently strong to hold the whole load. When one cage is at the landing of the second floor, the other cage is at the landing of the third floor, one going up and the other coming down, meeting at a midway platform between two floors. At this place the passengers change from one car to the other, those going up taking the car for the upper section, and those coming down the car that will land them on the second floor. By this means each cage moves up and down only half the distance between the second and third floors. The method of propelling the cages is by two rams which carry the cage from the midway platform to the third floor. These rams are a little more than twelve inches in diameter and have a movement of 263 feet, which is equal to the distance traveled by each cage. They are made in sections of steel about four feet long, riveted together, except the lower portions, which are made of cast iron on account of the extra weight necessary to counterbalance the other cage and its load. To protect the rams when extending out of the cylinders. guide columns are attached to the tower on each side of the cages, which are bored out to receive the rams, an opening or slot being left on one side, which serves as a guide for the cages. Attached to the under side of the cage is a cross beam pivoted in the center so as to insure easy motion, although there might be a slight variation in the movement of the two rams. The safety of this elevator depends upon the great factor of safety in the cables.

Each cage holds sixty-three persons and moves about 110 feet a minute; they were designed to work 177 feet per minute. I remember a lady weighing 250 pounds standing beside me in one of the trips upward, tremblingly asking me if I supposed it was safe and I assured her that it was safer than traveling fifty or sixty miles per hour on a railroad train, and after that she seemed to have more confidence in the elevator.

I was very much interested in an aneroid barometer placed in the cage, and as we went up the hand on the dial kept moving until it made nearly

$^1/_6$ of a turn from the place of starting and showed conclusively, that we were making rapid progress upward. The total capacity of the elevators of the tower is 2,350 persons per hour for the first and second stories, and

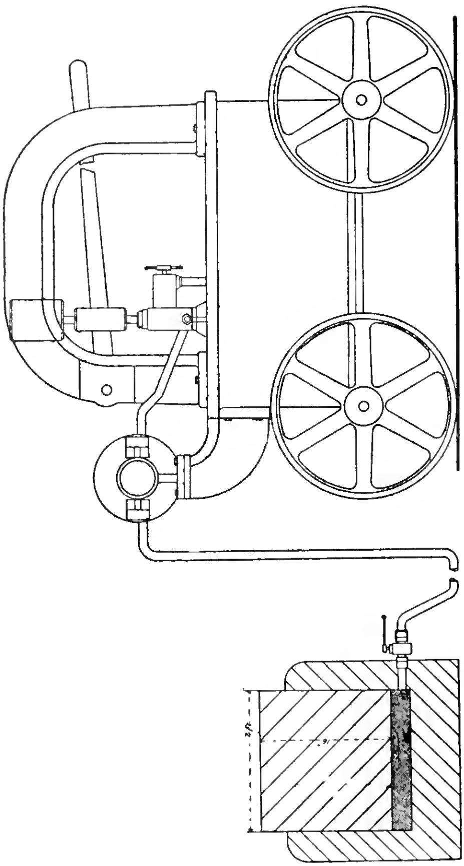


FIG. 7.

HYDRAULIC RAM.

750 persons per hour for the third story. The time to ascend from the ground to the top being seven minutes, although there was usually such a crowd ready to go up one was obliged to wait for an hour or two.

The engines and pumps that furnish the water for all the elevators are placed in the base of one of the columns, entirely out of sight from the public and I presume that most people had no idea of how or where the power was generated for doing all of that work. Two 150 H. P. pumping engines with Wheelock's Valve Gears, several laige steam pumps made by Worthington, and other engines and dynamos for electric lighting with boilers for furnishing steam, amounting to about 500 H. P., were located in the base of this one foundation and not a particle of steam or smoke was to be seen from the outside, the smoke passing underground several hundred feet to the river, and when asked how they first got up steam having to use a forced draught, we were shown a gas engine standing in one corner to which was attached a blower, which answered the question.

The illumination of the tower at night was very beautiful. Rows of gas lights covered with white porcelain globes outlined the foundation, the great circular arches of the first stories, also the balconies of the several stories, and near the top the two Mangin projectors arranged to throw a flood of light in different parts of the city or grounds, illuminating everything as bright as day and then reducing it to a small pencil of light, and above all the great revolving lantern, throwing out alternately flashes of red, white and blue light for miles around, the whole making a magnificent spectacle never to be forgotten.

Finally the tower is so constructed that should any of the foundations settle, it can be easily leveled and always kept in a vertical position. The means employed for this purpose were to me the most interesting of all.

Cast iron bases measuring three feet high and seven feet square at the bottom, rest upon the capstone of the foundation piers. These bases are in the form of sockets, measuring thirty-six inches inside diameter, into which the corner posts of the columns fit, entering the sockets about one foot, when heavy flanges around the post come against the top of the socket or base, these flanges supporting the whole load of the tower.

When it becomes necessary to change the level of the tower, these corner posts are forced out of their sockets and steel wedges or plates are filled in between the flange and the top of the bases. In order to raise this great weight, four portable hydraulic rams, Fig. 7, were constructed so as to be placed within the bases of the columns. These rams are two feet in diameter, working in cylinders having an outside diameter of three feet. As they require but a very short stroke, they are made very compact, measuring over all but about two feet in height. After these four rams are placed under the corner posts of one column a portable hydraulic pump is attached to them, which can be worked to a pressure sufficient to give each ram a lifting capacity of 1,200 tons. As the tower weighs 7,500 tons, it can be easily adjusted with the combined force of the four rams. The rams being portable, they can be taken from one column to another, thus forming a ready means for keeping the tower exactly perpendicular.

No doubt but this structure will be one of the great sights of the world

for many generations to come, yet Mr. Eiffel has so constructed it and provided for the constant change going on in its foundation that its great feature will never be that which has attracted so many people to the famous leaning tower of Pisa.

DISCUSSION.

Mr. Barber:—Has it ever become necessary to use fillers?

Mr. Swazey:—I cannot answer in regard to that. It shows in the rough sketch a workman in the position of putting in fillers. We noticed in the base fillers were put in.

Mr. Searles:—Inasmuch as I had the pleasure of visiting this tower, possibly something would be of interest from myself. This scale gives you some idea of the height of the tower but I think the best way is to compare it with some object which you are already acquainted with, the Electric Mast, which is 250 feet, and you can readily see where it would come on this tower. The writer of the paper has referred to the difficulty when at the top of this tower, to distinguish objects on the ground with the naked eye, and we form a tolerably correct idea of it, when ordinarily we can see half a mile away and tell what the object is, but from this height looking down within a radius of forty-five feet from the tower, it is impossible to distinguish anything. When I was up in the tower there was a cavalry drill going on down below, and I was under some hesitancy to know what it was, but taking my opera glass I discovered what it was. I would hardly believe it was so difficult to distinguish objects from the height looking down until I had the experience. The sight of the tower when lighted up has been described, but it takes the pen of a poet to describe it at night. It is a thing of beauty and grace which is not in the power of an engineer to describe.

ASSOCIATION OF ENGINEERING SOCIETIES.

PROCEEDINGS.

BOSTON SOCIETY OF CIVIL ENGINEERS.

JUNE 18, 1890.—A regular meeting was held at the American House, Boston, at 19:45: Vice-President Freeman in the chair. Forty-nine members and twenty visitors present.

The record of the last meeting was read and approved.

The following were elected to membership: Messrs. Francis Blake, Frank P. Johnson, George H. Nye and George C. Stoddard, as members, and Mr. Edward P. Fisk as an associate.

Mr. Hiram F. Mills, C. E., member of the State Board of Health, was then introduced. Mr. Mills read a paper entitled "Purification of Sewage by Filtrature and by Chemical Prescription," giving the results obtained at the Experimental Station of the Board of Health, at Lawrence, during the past three years.

On motion of Mr. Brooks, a vote was passed extending the thanks of the Society to Mr. Mills for the interesting paper which he had read.

Mr. Charles A. Allen read a short paper describing the Sewage Disposal Works which he had just built in Worcester, Mass.

Mr. Wilbur F. Learned read a paper showing the results obtained by the chemical treatment of sewage at Winchester, Mass.

After discussing the several papers the Society adjourned to the third Wednesday in September.

S. E. TINKHAM, Secretary.

ASSOCIATION OF ENGINEERING SOCIETIES.

ORGANIZED 1881.

Vol. IX. September, 1890. No. 9

This Association, as a body, is not responsible for the subject matter of any Society or for statements or opinions of any of its members.

THE ELECTRICAL TRANSMISSION OF POWER.

BY EUGENE GRIFFIN, MEMBER OF THE BOSTON SOCIETY OF CIVIL ENGINEERS.

[Read Feburary 19, 1890.]

The conservation of energy, the conversion of energy and the transmission of energy are three of the great principles, on which depend the the past, present and future of the universe.

Energy cannot be created and cannot be destroyed. The total energy in the universe is the same now as it was yesterday, and as it will be to-morrow. Its manifestations alone are subject to change.

Energy is readily and easily converted from one form to another. Emanating from the sun as ethereal waves, it is caught and imprisoned in the depths of the coal mine, only to be brought forth ages afterwards by the delving miner and divorced from the inert material under the boiler to undergo another change into the watery vapor we call steam. From this form we obtain mechanical energy through the transformation effected by the modern steam engine. Again it may be converted into the subtle electric current and then transformed into light, heat or mechanical energy.

The touch of the magician's wand is not more potent in its results than the application of man's inventive faculty.

The problem of the economical transformation of power is as old as the world. We use no form of energy that is not transmitted a greater or less distance. As we state the problem, we really mean the transmission of power over considerable distances. The demands for such transmission of power in commercial life, are too numerous to classify; but among the most important, we may mention street railway propulsion, mining work and mill work.

The practical development of the system of transmitting power by electricity dates from 1873, when the Gramme Co. demonstrated at the Paris Exposition the possibility of using one dynamo as a motor driven by a current from another dynamo. The demonstration was a practical one, as the length of the connecting cable or wire was over two kilometers. Only seventeen years have elapsed since the commercial possibility of transmitting power by electricity was first shown. What wonderful developments have been made within this period? No other art, science or invention can show a record comparable with this.

To-day we give but a passing thought to the fact that $8,129, 787, 731. are invested in steam railways in the United States alone; yet it has taken sixty years to bring about this development.

The steam engine was a scientific toy for many years before it was applied to practical purposes. For a hundred years we have been improving the steam engine, and even now, we can only utilize 15% or 20% of the heat units in the coal we burn. The dynamo, on the other hand, gives us an efficiency of 90% or 95%.

With a single bound it has reached the front rank. Overwhelmed with the commercial demands, the electrical engineers have been given little time to develop, to change, to improve; but so perfect was the original product that fortunately the limits for improvements, so far as commercial results are concerned, are narrow.

We should recognize this enormous pressure on our electrical factories, this enormous demand for apparatus, and be lenient with present defects, not condemning because the apparatus is not perfect, but rather regarding with amazement the rapid development and the high standard already reached.

Sixty years ago, Michael Faraday found that by revolving an iron plate or disk in the field of a magnet, connecting one end of a wire with the centre of the disk and brushing the other end on the circumference, a current of electricity was set up in the wire when the disk revolved. This was the dynamo electric machine. The modern dynamo is but a development of this type. Coils of wire are revolved in the fields of powerful magnets and a current is generated in the wires; which current can be carried by lead wires, one, two or more feet, or one, two or more miles. It is is by the aid of this machine that we are now enabled to transmit power to very considerable distances, with economy, reliability, efficiency and safety.

The feasibility of transmitting power over long distances by the aid of electricity, means many advantages when steam is the prime power. It enables us to locate the steam plant by the water side, where compound condensing engines can be used and where by concentration of stations, we can use large engines with the greatest economy in coal consumption. It enables us to save materially in our real estate investment. It enables us to locate near the railroad track or the wharf, where coal can be delivered direct, without cartage. It enables us to keep out of the heart of the city where power stations may be objectionable, both on account of noise and smoke. But these advantages, great as they are, are nothing com-

pared with the possibilities in the way of utilizing our water powers.

According to the census of 1880, we were using in the United States, 55,404 water wheels with a total consumption of 1,225,379 horse power. This was 35.93% of the total power employed in manufacturing. In the same census report, the total theoretical water power of the United States is estimated as 200,000,000 horse power.

If we assume 5% as practically available throughout the year, we have a total available water power of 10,000,000 horse power, of which, probably, not over 1,350,000 horse power is used at the present time. The margin for the future is 8,650,000 which is certainly not an over estimate. and yet it is 2½ times as great as the total steam and water power combined in use in 1880.

The water powers which we look forward to utilizing in the future, are not all in the West, in the country yet to be developed, though the Northwest is exceedingly rich in this respect. There is much to hope for right at home. In 1880, the condition of affairs in New England was approximately as follows:

	Utilizing in 1880.	Undeveloped.	Total Available.
Horse power of over 10,000	5	3	12
" " " " 5,000	7	10	29
" " " " 2,000	13	16	38

Right here in New England, we are probably not utilizing more than half of our available water power. It is impossible to give any exact data as to the relative cost of water and steam power. The cost of water power varies largely with the location, the natural obstacles to be overcome, the conditions of the dam, canals, etc., governing the cost of maintenance and a thousand and one details that will vary with every case. In Passaic, Paterson, Trenton and other New Jersey cities, water power costs from $50 to $80 per horse power per annum; yet it is found economical or at least advantageous to use at these prices. Elsewhere water power runs as low as $10 per annum per horse power, and in many cases even lower yet. In general, we may say that water power is cheaper than steam, and this is especially true of those powers yet undeveloped, which are situated at distances from large communities or where the natural obstacles prohibit their local use.

Electricity is specially adapted for use with such powers, and may be used in one of two ways. The dynamos driven by the water-wheels may be connected by wires with the neighboring city mill or mine, where the power is to be utilized, or the electrical energy developed may be stored in batteries for distribution throughout the city. I do not regard it as at all improbable that some day, the retail dealer may take our order for jars of electricity as he now takes it for quarts of milk. The storage battery needs much development before such a system of distribution is possible, and the conditions giving cheaper power and cheap transportation must be very favorable to make it economical. Moreover, it must always be restricted to small powers. For large powers the direct system will be used. If the distance be not too great, electrical energy may be developed at the desired voltage and so transmitted. If the distance be too great or

the quantity to be transmitted too large, a low voltage would be out of the question on account of the cost of the immense mass of copper necessary to carry such quantity. In such case we should use a high voltage, 4,000 or 5,000, the proper voltage being a question for mathematical determination. As the horse power is a function of the product of the voltage and the quantity, and the carrying capacity of the wire is measured by the quantity alone, it is manifest that by increasing the voltage we increase the horse power, and so can transmit more energy over the same wire. With a given size wire capable of transmitting a given quantity of electricity with a given loss, we can by increasing the voltage only, increase the power transmitted without changing any of the conditions. Therefore a high voltage is desirable, necessary and economical, when power is to be transported long distances. The high voltage is dangerous to life, is dangerous to the machine, and is more difficult to insulate. These are the objections. A careful consideration of the relative advantages and disadvantages and a mathematical calculation on the cost of wire, will enable us to determine the most economical conditions. When the interest on the investment in copper is just equal to the cost of generating the power wasted in transmission, the point of ultimate economy is attained.

The alternating current may be used for such transmission, as it admits of immediate conversion to any desired potential by aid of the transformer. This current is, however, not suited to power work and, in general, we must depend upon the direct current. Under the conditions supposed we must establish a station in the city where the current transmitted from the original station is made to run large motors which in turn drive arc and incandescent lighting machines, power dynamos, etc. The circuits from these machines are established as usual. Let us see what the loss would be in such a system. Assuming an efficiency of 80 per cent. in the wheel, an efficiency of 92 per cent. in the dynamo, a loss of 15 per cent. in the line and an efficiency of 90 per cent. in the motor, we have:

Total water power applied to wheel	100 h. p.
" power applied by wheel to dynamo	80 "
" output of dynamo	73.6 "
" power applied to motor at city station	62.6 "
" output of motor	56.3 "

This is assuming that we purchase water power or rate it on the basis of theoretical capacity. If we compare the wheel output with the steam engine output, we have the following:

Total power applied by wheel to dynamo	100 h. p.
" output of dynamo	92 "
" power applied to motor at city station	78.2 "
" output of motor	66.5 "

The output of the motor is applied directly to the working dynamos, as would be the output of a steam plant at the station. It would appear, therefore, that the system of transmission and conversion entails a loss of

power of 33.5 per cent. The interest on first cost of plant, the cost of maintenance and the cost of generating under the two systems, will show which is the cheaper. Let us make a comparison.

If, by going five miles away we can get water power, will this be cheaper than to furnish the power direct by steam, supposing 1,000 horse power be required?

Assuming the steam plant complete to cost $50 per horse power, the investment will be $50,000. The cost of operation will be for an economical plant, about $32 per horse power per annum. From this we have the following:

Cost of steam plant		$50,000
Interest and depreciation on plant	$ 7,000	
Cost of operation	32,000	
Total		$39,000

That the motor by the system of transmission may yield 1,000 horse power it is necessary that 1420.86 horse power be applied to the dynamo by the wheel. Assuming that the cost of the water power plant complete is $50 per effective horse power, we have:

Cost of water power plant	$ 71,043	
" dynamo plant	33,000	
" line	6,000	
" motor plant	30,000	
Total cost		$140,043
Interest on investment	$ 8,402	
Depreciation	6,606	
Cost of operating water and dyamo plant and motor plant	16,000	
Total		$30,402

Even this shows economy over the steam engine. Should we combine both methods and let the water power plant run all night to charge storage batteries, then we have an additional economy which may be of very great importance.

These figures are, of course, simply estimates. All that I desire to prove is that it is possible, by the aid of electricity to utilize water powers located at considerable distances from the point where the power is to be used, even when such transmission entails a double conversion. The cost of water power plants is as variable as the plants themselves, so that any estimate must, of necessity, be very general.

Many of you have doubtless seen Prof. Kennedy's paper on the transmission of power by compressed air, read before the British Association for the Advancement of Science, last year. He discusses the Poff system in use in Paris, where a central station supplies motors within a radius of three and four miles. He finds that the efficiency of the compressors is about 61%; of the mains and valves about 96%; and of the mo-

tors when not less than 5 horse power about 78%. This would indicate a total efficiency of 45.7 horse power. The Professor says:—"The rate of charge is 1.5 centimes per cubic meter for air used in motors, which is equivalent to nine cents per 1,000 cubic feet. In addition to this, a fixed charge of from 100 to 200 francs is made for pipes and connections." "The air actually used was 665 cubic feet per indicated horse power per hour."

This would indicate a direct charge of six cents per h. p. h. and an indirect charge for pipes and connections, the amount of which cannot be easily determined. Six cents per h. p. h. is equivalent to $219 per horse power per annum, 10 hours per day.

The indicated efficiency of the whole process with cold air is given as 39% and with heated air 47%. We have in Boston and in most of our cities, similar systems of distribution by electricity and the charge for motors of 5 horse power and upwards, for general intermittent work, is from $82 to $60 per horse power per annum. Distributing circuits vary from 110 to 500 volt currents and motors are used from a small fraction of a horse power up. These motors are used for all purposes, to drive ventilating fans, run elevators, printing presses, sewing machines, coffee mills, etc.

There is no limit to these general applications. Where large central power plants have been established, it is found that power can be sold considerably in excess of the station capacity, as so many of the motors are intermittent in their demands that we are never called upon to supply the full power contracted for. This means better profit on the investment and cheaper power to the consumer. It is probable that the electric motor will soon supersede the small portable engine now used in dock hoisting work, in building construction, and in similar situations. The greater portability, economy, efficiency and safety make such substitution only a matter of time. For all local purposes where small powers are required, the motor is not only more economical and safe, but it has another decided advantage, namely cleanliness. The electric motor is a neat and even ornamental machine and many users speak in quite as glowing terms of its advantages over steam in way of cleanliness, as of its other points of superiority. Its use is spreading in all our cities, and the demand far exceeds the capacity of our factories.

MINING WORK.

For mining work much is expected of electricity, and much has been done. In this field it has the advantage of applicability to all power purposes. It lights the mine, hoists, drills, cuts, pumps and hauls. The wires are small and occupy but little space; they do not get out of order: they are flexible, easily added to and extended. In every respect, electricity is superior to compressed air, its only competitor in mining work, with perhaps the sole exception of ventilation. Electricity does not consume oxygen, but compressed air is not limited to this negative benefit; the fresh air from the motor exhaust is a very positive benefit. The original cost and cost of maintenance of a compressed air plant are, how-

ever, greater than of an electrical plant; its economy is less and its lack of flexibility is a further drawback. It is not as easily applicable to the tramways.

Hoisting.—For hoisting purposes the application is so simple and so direct that it requires little consideration.

Pumping.—There are now many mines where electricity is used for pumping purposes. In the plant installed in the Trafalgar Collieries in 1887, the following results were attained:

When the pump was being driven at 25 strokes (112 gallons) per minute, the indicated horse power of the engine was 29½ and the actual horse power of water lifted 10.36. Including a loss of 22% in the engine, the total efficency was 35%. The loss in the dynamo was 20%, a degree of inefficiency unnecessary and not characteristic of good machines. The cost per 1,000 gallons of water raised was 3.7 cents. In this case the pump was fixed 1,650 yards from the bottom of the shaft.

In February, 1888, a pumping plant was installed in the St. John's Colliery, Normanton, designed to raise about 7,200 gallons per hour through a vertical distance of nearly 900 feet at one lift. The pumps work 22 hours out of the 24, and the whole plant has shown a commercial efficiency of 50%. This plant replaced a smaller installation driven by compressed air, which did not give 20% efficiency, and the engineer estimated that to do the same work by compressed air would involve a first cost, at least, 25% higher and double the engine power.

Haulage.—There are now many mining installations in this and other countries using electric haulage. As this differs from street railway traction in details only, not in principle, it is not necessary to notice it here.

Coal Cutting Machines.—There are several coal electric cutters now in the market, and much attention is being given to this machine. I do not know that it has been developed to a perfectly satisfactory point yet, but if not there, it will soon get there.

Drilling Machines.—Electricity has been applied to drilling machines, both impact and boring. The greatest demand seems to be for the percussion drill. We are now developing a drill constructed on the Solenoid principle which drills a two-inch hole in granite with rapidity and economy. The extensive use of such drills in ordinary excavation and tunnelling, as well as mining, opens an immense field to the electric motor. A permanent and sheltered location for the steam and dynamo plant, the economy of operation, and the great flexibility of this system, makes the general use of electricity for drilling purposes a certainty.

The installation at the Big Bend Tunnel Camp, California, is an interesting one, as illustrative of many of the advantages of electricity. A tunnel 16 feet by 12 feet, and 2⅓ miles long, is cut from the Feather River through the mountain, a permanent dam built across the river just below the head of the tunnel diverts the whole stream into the tunnel, and a canal, two miles long, extending from the other end of the tunnel, makes it possible for a fall of 300 feet to be obtained. Here the dynamos are driven by powerful water wheels, developing 1,000 electrical horse power. The

conductors are double metallic, extending a distance of eighteen miles, delivering electricity at fourteen different points in the circuit where power is required for winding, pumping, etc.

MILL WORK.

In the application of electricity to mill work, we find many advantages of which a few are:

1. The possibility of selecting a mill site without regard to the power and solely with reference to other and economical considerations, such as, character of foundations, transportation facilities, cost of real estate, etc.

2. The possibility of concentrating power from two or three different sources to use at one point, as for example, the utilization of several small water powers.

3. The possibility of dispensing with belting and shafting.

4. The possibility of removing engines and boilers from the immediate vicinity of the mill, an advantage of great importance in the manufacture of certain fabrics and a saving in insurance.

5. An actual saving by sub-divisions of power to any desired extent.

Under the old system we must place the mill where the power is, however unfavorable the considerations. With electricity we seek the most favorable conditions for location and transport the power to the mill.

By the use of several small powers we obtain an aggregate sufficient for the purpose, or we concentrate several small mills into one large one, with a great gain in economy of management and operation.

We can do away entirely with belting and shafting, though it is doubtful if true economy dictates a motor to each machine. I quote the following rules which seem most excellent ones for the determination of the limits of the use of wires and separate motors in place of shafting.

1. Let electrical distribution displace every mechanical means for angular transmission. It loses no efficiency in going round a corner; mechanical transmission does. Bevel gears and quarter turn-belts take room, are expensive, require much care, and wear out rapidly; a copper wire is practically everlasting, is inexpensive, takes little room, is hardly noticeable, and requires no care.

2. Let it displace mechanical means in any case where the question is simply one of transmission. It requires no hangers, no bearings, no oiling, and never gets out of line in such manner as to absorb more power.

3. With rare exceptions, let it displace all counter belts. Once in place, the conductor is there to stay; never breaks, never slips, never has to be taken up, is always ready to start, and never loses its initial efficiency.

4. When individual machines require 10 horse power, or are run intermittently, use a motor for each. Such absorbers of power as idle belts and shafting are thus avoided. It is a peculiarity of electrical transmission, that no power is consumed by, and therefore none transmitted to, motors that are idle.

As illustrating the advantage of separate motors on intermittent machines, such as are used in many mills and on all city power circuits, I quote the following from an account of the operations of an electrical installation in one mill.

"The power which would be required to operate our factory in the usual way, by belting through the floors, was estimated by several engineers, competent in factory construction, to be between 30 and 50 horse power; without considering the power required for our lights, amounting to an additional 15 horse power. In other words, we are delivering an estimated 50 to 70 horse power and only developing 15 to 30 horse power, with an average of but 17 to 18 horse power for ten hours."

"Whence comes this apparent something for nothing? I will try and explain to you. Every operator in our factory who has charge of a machine, be it a milling machine or a drill press, a lathe or a planer, has a certain and absolute direct and instantaneous control over the automatic valve gear on our engine in the basement through the medium of his belt-shifter. We will suppose he is using a milling machine; the piece being milled has finished its travel, and the machine is stopped. A horse power of duty has been taken off the motor driving that machine. Multiply, if you please, the ¼ horse power hours (supposing it to be stopped 15 minutes each hour), by say 50 machines, running under the same average conditions, and you have a total of 12½ horse power hours saved each hour. Add this 12½ horse power to the 18 horse power, our average load, and we begin to approach the estimated load of our factory under former conditions of practice. To this we should add about 12 or 15 horse power, which would be necessary to drive a line of heavy main belts through the six floors of our factory; and we have a gross result of 42 to 50 horse power."

TRAMWAYS.

The electrical propulsion of street cars is perhaps the most important branch of the electrical transmission of power at the present time. In 1885 there were three roads with an aggregate mileage of 7.5 miles and 13 cars. On January 1, 1890, there were 251 roads in operation and under contract with an aggregate mileage of 1,641 miles and a total of 2,346 cars. This represents but five years' growth. The increase in this application of electricity, like most of the others, is limited solely by the capacity of the factories. On July 4, 1888, the Thomson-Houston Electric Company started its first car. Now we are turning out 50 railway motors per week and our total production is already sold up to the first of July next.

The overhead system is almost exclusively used for street car propulsion. Conduits have not been successful, up to the present time, and the development of a reliable, economical and satisfactory storage battery is a matter of the future.

Is electricity a dangerous form of energy? Statistics show that it is not.

During the past year the deaths from violence in New York City

aggregated 1,467. Of these, 265 resulted from falls; blows from falling objects, 36; run over by horse cars, 12; run over by cars and engines, 33; run over by wagons and trucks, 32; asphyxiated by gas, 12; and killed by electricity, 9.

During the year covered by the last report of the Board of Health, the total number of deaths in Boston from casualties aggregate 399. The railroads were responsible for 78; 60 were drowned; 13 were run over by vehicles; 9 were kilted by elevators; 12 died of the effects of heat, and no less than 78 were killed by simply falling down, of which 16 fell down stairs; 7 fell on the sidewalk; 6 fell from buildings; 5 fell from teams; 4 fell on the ice;; 1 fell from a chair; 1 fell from a tree; 1 fell from a bicycle; 1 from a fence, and so on. Not a single death is recorded against electricity. There are in New England 131 are light central stations, which have been in operation from one to ten years, burning over 20.000 arc lamps and distributing thousands of horse power by wires through and over all the principal cities and towns. During this period there have been but five deaths by electricity. What other industry comparable with the electric industry can show such a record for safety? During these ten years, the steam roads of New England have killed and injured no less than 5,241 human beings. Of the five deaths by electricity, four were employees of the lighting companies, and one only can be classed with the public. Of those killed or injured by railroad accidents, 2,329 were employees and 2,902 were general public. Not only is electrical energy absolutely safer than any simular quantity of energy used in our industries, but it is relatively safer, as even the few deaths that do occur are among the employees, and in general, are caused by neglect of instructions and failure to observe the necessary precautions.

Another objection urged against electricity, is the danger of fires. It is common now to attribute every fire to electric wires when the cause is not clearly apparent. Let us examine the statistics on this point for the past few years.

Since the establishment of the office of Fire Marshal in Boston, its present incumbent has investigated, in the most thorough manner, every fire, and has given us a record as to causes probably as complete as it is possible to obtain. From November 8, 1886, to May 1, 1887, 344 fires were investigated, of which only 5 are returned as "cause unknown." The kerosene lamp caused 32; rats and matches are responsible for 11; dropping of matches 27; children and matches 13; careless use of matches 12; overheated stove 16; hot ashes from tobacco pipe 10; lighted cigar stumps 6; sparks from locomotive 3; and electric wires 3. Electricity caused .009 of the fires. For 1888 we find the same record for kerosene, matches, rats and matches, while electric wires are responsible for only .007 of the fires. In the 1889 report, sparks or heat from furnaces, locomotives, steam pipes, etc., are responsible for 14% of all the fires; kerosene stands well up with 13%; while matches in conjunction with men, rats and children, are responsible for 20% of all the fires. Electricity comes in with a modest 2%, being on a par with hot ashes, and twice as harmless as fire crackers and fireworks.

Such a record should exonerate the electrical wires from the charges brought against them.

The above refers to electric wires in general. Now a few words as to the electric railway wires.

While the arc light wires carry currents of from 2,000 to 6,000 volts, the railway wires carry a current of only 500 volts. This voltage is fixed and the quantity of electricity varies according to the needs, *i. e.*, according to the number of cars running.

While human beings have been and may be killed by arc light currents, it is an incontestable fact that no man, woman or child has ever been killed or even seriously injured by a 500 volt current, though many have been subjected to the shock. Every alleged case of death or injury by railway wires, has, upon investigation, been shown to be without foundation, or else to have been caused by the arc current. I might cite the case of the colored boy said to have been killed by the railway wires at Chattanooga. He was found in a pit beneath the car he had been employed to clean, with his clothing on fire and an overturned oil lamp between his legs. He burned to death. This occurred in the night, an hour and a half after the road had ceased running and the power station had shut down. There was no current in the wires. and had been none for an hour and a half, yet this death has been repeatedly ascribed to railway wires. While hundreds have taken the full 500 volt current, no one, not even a child who held a contact wire for four minutes has ever been seriously injured.

In the report of the Commissioners of the District of Columbia on the Eckington Railway, a report made to Congress, they state: "The Commissioners believe that the electrical system employed by this railway, the electro-motive force of which can never exceed 500 volts, is as safe as any motive system ever employed by any railway. The Eckington Railway has never had any accident whatever resulting from its employment of electric motive power, and the Commissioners believe this to be also true of all other electric railways, now in operation throughout the United States."

As to danger of fire, since the railway wires enter no buildings, they cannot of themselves cause fires. The current might be conveyed through some other circuit by wires falling on the trolley wires. Without discussing the law and equity of requiring such wires, when they cross the streets or cross other wires, to be so put up that they will be safe, it suffices to say that by the use of guard wires, we prevent falling wires from coming in contact with the trolley wire, and the chance of a railway wire causing a fire, either directly or indirectly, is so remote that it will probably not be found worthy of a separate classification in the list of "causes." Every electric wire entering a building should be provided with a fuse or short circuiting device, so that stray currents of greater voltage or quantity than the normal will be effectually cut off.

IS ELECTRICITY AN ECONOMICAL POWER FOR STREET RAILWAYS?

Electricity shows a very considerable saving over animal power. Of

100 h. p. produced in the steam engine, 92 is converted into electricity and goes out of the station over the line as electrical energy. The loss in the line need not exceed 10% though in some cases it may be economy to allow a larger loss. We have thus 82.8 h. p. delivered to the motor on the car. If the average commercial efficiency of the motors and gearing be 75%, we have 62.1% horse power utilized in moving the car, or a total efficiency of 62.1%. In some cases, of course, we fall below this figure. The actual power required per car depends upon the grades, the speed, the curves, the kind and condition of track, the average load, etc., conditions so variable that it is hopeless to try to determine any average figure. The power will range from 4 h. p. to 8 or 9 h. p. under ordinary conditions, and may increase very considerably under extraordinarily bad conditions. The cost of power at the station depends upon the kind and size of the engines, the price of coal, the management of the station, etc. It ranges as low as nine-tenths of one cent per car mile. The cost of repairs depends very largely upon the care bestowed upon the apparatus, and any figures given without a full statement of all the special conditions would be misleading.

Speed is not only an important factor in determining the value of electric railways to the public, but it is equally important to the railway manager as a source of economy. If we average six miles per hour with horses, and nine miles per hour with electricity, it is evident that in the latter case one car does 50% more work with a corresponding saving in the item of wages of conductors and drivers.

In the crowded city streets we cannot hope to gain much speed. In the suburbs the gain is only limited by considerations of safety. From Harvard Square in Cambridge, to the end of the line in Arlington, the electric cars average nearly 11 miles per hour, including stops—better time than is made by the elevated roads in New York City. On the Watervliet road, between Albany and Troy, the cars averaged 139 miles each per day, during the month of December 1889, and have averaged 186 miles each for one day.

This, however, is an imposition upon the motors. It is requiring more than we ask of the steam locomotive, which runs, under the most favorable conditions as to grades, curves and track. I give these figures as an instance of what can be done and what is done, not as an example of what should be done.

By the aid of electricity we have increased the average speed of the cars in Boston from six miles per hour to eight miles per hour, and were all the cars equipped electrically, this increase alone would make an annual saving to the passengers of 4,152,000 hours or about 474 years. Think of this, as one year's saving in one city, resulting from the use of electricity as a motive power for street cars. As a matter of fact, the gain in speed will be greater when all the cars are equipped, as the average is now kept down by the horse cars holding back the electric cars running on the same tracks.

The increased speed should not be lost sight of in comparing the cost of operating electric with the cost of operating horse cars. A compari-

son on the basis of car days is not a just one. The comparison should be made on the basis of car miles. On the Watervliet road the daily mileage per car has been nearly doubled.

Another economical feature of the use of electricity is the ability to haul one or two tow cars. We can double or even treble our carrying capacity in case of emergency, and the extra plant kept for such purposes is in the cheapest form, representing a comparatively small invested capital and subject to but little deterioration. Compare this with the cost of keeping extra horses, sufficient to double or treble our carrying capacity. The difference is enormous.

On these roads or lines where the traffic is great and constant, we will have larger cars. By using the radial truck or double trucks, we can handle 30-foot cars as easily as our present standard form, and do away with the annoying and destructive teetering, inseparable from a long car mounted on a six-foot truck. We can nearly double the seating capacity and still use but one conductor and one driver.

From the foregoing it is evident that electricity admits of many economical changes and that in many ways we may hope to reduce expenses by its use, at the same time giving better service.

IS ELECTRIC RAILWAY APPARATUS DURABLE?

A Van Depoele road was put in operation at Lima, Ohio, July 4, 1887. So far, the apparatus has shown no signs of wearing out. The Eckington & Soldiers Home Railway in Washington was started Oct. 17, 1888. Senators and representatives say it is the finest street railway in this country. The Omaha & Council Bluffs Railway was opened to traffic in October, 1888, with ten cars (20 motors). Of these motors not a single armature or field has been lost, with the exception of a few struck by lightning before being properly wired for the lightning arrestors.

There are certain parts which we expect to wear out, the gears, the shells in the bearings, the trolley wheels, and so forth, but these are provided for. The iron frame of the motor has no wear, and should last indefinitely unless accidentally broken. The field and armature are not subjected to wear and should last indefinitely unless burned or injured by accident. The electrical part of the apparatus is all right; such wear as we find is mechanical. It is the mechanical rather than the electrical engineer that we look to for improvements.

We have to a great extent eliminated the electrical difficulties and reduced the problem to one of mechanics.

ARE ELECTRIC CARS RELIABLE?

That some difficulties are encountered in the operation of electric cars cannot be disputed. Even though these difficulties, these mishaps, these accidents be slight, if they interfere materially with the regular operation of the cars, if they cause breaks in the schedule, then they are matters for serious consideration and perhaps for more serious consideration than the actual cost of repairs involved. It is difficult to secure data in reference to lost trips on roads which are operated independently of the electric

companies. On the West End road in Boston, during the months of June, July, August and September, 33,665 round car trips were made, covering a total milage of 364,754 miles. *Not a single trip was lost.* This is certainly a satisfactory record, as to reliability. Similar results have been obtained on many other roads, but the West End is perhaps one of the most difficult of all the roads to operate electrically.

On a purely electric road, if a car breaks down from any cause, the next car pushes it home and the delay is slight. I saw one day on Boylston street a string of horse cars blocked by the cutting of a ditch across the street. Each car, as it came up, had the horses removed and driven around, while the car was pushed across by hand. This entailed much delay and five cars were soon collected in line. Then an electric car came along, the horses were all removed and the electric car pushed the five cars across at once. Here was an unexpected example of how time may be saved by electricity.

The behavior of the electric cars in snow storms is remarkable. It is really astonishing to see the cars running through twelve inches of snow with no apparent difficulty, frequently pushing or pulling other cars, while four steaming horses are hardly able to pull one car. The contrast is great, and many who were doubtful about the ultimate value of electricity last fall, are most enthusiastic advocates now.

During the recent blizzard in St. Paul one of the criticisms of the electric road was, that the drivers lost their heads and cut down the schedule time of the round trip from 45 minutes to 35 minutes.—certainly not a cause for serious complaint. In St. Louis, in Wichita, in Kansas City, in Omaha, in Council Bluffs, in Scranton, in Syracuse and elsewhere, the electric cars have this winter demonstrated their decided superiority over horse cars, and have shown their ability to run through ten or twelve inches of snow, without requiring the tracks to be cleaned. The electric sweepers in this city are a pronounced success, and the press, the public, and the railway officials are unanimous in their praise. We feel confident now that electric cars can run when horse cars cannot, and that it will require such an unusual storm as stalls the steam roads to block electric cars.

To insure reliability, the entire system should be constructed and installed in a first class manner; duplicate or reserve steam and generator capacity should be provided; extra motor cars should be held in reserve, the proportion depending upon the nature of the service required; and extra parts should be kept on hand so that an accident can be repaired in the shortest possible time. We should realize that to a certain extent the motors take the place of horses. A motor may fall sick occasionally and the services of an electrical doctor should always be available.

WHAT IS THE FIRST COST?

The cost of equipment of a first class double track road, including iron poles (side suspension), 56 lb. girder rail, one 16-foot closed car and one open tow car to each mile of track, suitable generator and steam plant capacity, etc., would be approximately $20,000 per mile.

On a road with bad grades greater power might be required. If wooden poles be used, the cost of the line would be very materially reduced.

The success of electrical propulsion has been established beyond question. It is only a matter of time, and that a short time, when it will replace the horses on the majority of our street railways. It is only a matter of time, a somewhat longer time, perhaps, when it will be the propelling power on all our elevated roads, for the elevated roads possess ideal conditions for the application of electricity. It is within the bounds of possibility that our steam roads will be run with electricity. Certainly this power offers many advantages for the suburban traffic. The possible utilization of hitherto neglected water powers will be one of the factors in determining the extension of electrical propulsion in this direction. Already we see the beginning. The West End Company of Boston are now building longer cars with radial and double swivelled trucks. The New York elevated roads are anxiously seeking a solution to the problem of how to enlarge their carrying capacity, without rebuilding or materially altering their superstructure. Longer trains are requisite to meet the increased demands. The limit of the capacity of the present locomotives has been reached. Increased weight in the locomotive means an immense expenditure for strengthening or practically rebuilding the roadway. Cables are not feasible, as the strain on the grip would not permit of long trains and it would be difficult to combine speed and safety with any considerable increase in the number of trains. Cables would not permit of satisfactory switching arrangements at the termini or elsewhere. Electricity offers the best solution. Equip each car with motors. Flexible electrical connections can easily be made from car to car as is now done on surface roads to light the tow cars, and the whole train controlled by the driver on the front platform of the leading car. Electric or vacuum brakes can be used in the same way. It matters not how many cars we have in a train—one or fifty. Each cars adds its own power and all work together. There is no dead weight to pull, as in the case of the locomotive. The passengers themselves furnish the weight for traction. The switching arrangements present no difficulties whatever. The motors can be reversed and run equally well in either direction. The train can be controlled from either end, and any increase or decrease in the number of cars will not affect the controlling mechanism.

It is difficult to conceive of a more feasible system. It seems to be the ideal system for the elevated roads and is bound to be adopted in the near future.

DISCUSSION.

The President:—We are all indebted to Captain Griffin for his kindness in preparing this paper and coming here to read it to us tonight. The matter is now open to you gentlemen for discussion, and I dare say Captain Griffin will be glad to answer any questions.

MR. G. W. BLODGETT:—I have enjoyed very much the reading of the paper, and it seems to me one of the most remarkable facts which confront us is the rapid development of electrical science, especially as regards the transmission of power. I had the honor to read before this Society, in 1880, a paper upon the then status of the transmission of power by electricity. It was before it had ever been applied to the propulsion of cars—with one exception, at the Berlin Exposition I think—and from the volume of the Society's proceedings which contains that paper it may be of interest if I read one or two little things which show the results that had been attained up to that time. The first point which is of interest is the increase in the efficiency of the dynamo machine. At that time the veteran electrician, Moses G. Farmer, who was perhaps as well qualified to estimate correctly the efficiency of a dynamo as anyone in this country, stated that he had obtained "as high as eighty-five per cent.; others claim more; some may go as high as ninety per cent. under especially favorable conditions; but from seventy to eighty per cent is a fair amount." The Brush Company at that time claimed as high an efficiency as 87.4 per cent. Dr. Paget Higgs claimed to have received from a Siemens machine about 90 per cent., exclusive of friction. (I would say in this connection that a dynamo machine which transformed into electrical current only 85 per cent. of the power which was applied to it would be deemed in this day too inefficient for economical use.)

I also gave a few instances of the actual employment of electricity, deemed of surprising novelty at that time, one of which was that on May 26, 1879, a field had been plowed at Sermaize, in France, by means of power transmitted by electricity four hundred and six hundred metres. At the Berlin Exposition in 1879, there was in operation a railroad 300 metres long, run by electricity furnished by a machine working in the large hall. This distance was traversed in two minutes by a train consisting of a locomotive and three wagons, in each of which six persons could be accommodated. In 1880, Sir William Thomson transmitted eight or ten horse powers more than a mile by electric current. Dr. Paget Higgs, in a letter, furnished me some interesting unpublished data, which were as follows: That he had transmitted 98 horse powers, with ten dynamos in all. This number was subsequently reduced by improvements, to two dynamos at each end of the wire, which was a copper were of three-eights of an inch in diameter, suspended on ordinary posts. The conclusions drawn, at that time, were that the electrical transmission of power was possible, and that an efficiency of 75 to 90 per cent. might be counted on in the transformation of power into current, and a nearly equal amount in the transformation into power again, making the *net* efficiency of the transmission from 40 to 50 per cent. of the original power.

One thing I have omitted to say was that in some of Dr. Higg's experiments he obtained an efficiency of the dynamo and motor combined of 39, 45 and 49 per cent., which represented the proportion obtained from the original mechanical power applied to the first machine, and the conclusion reached at that time was that about forty or fifty per cent. of the power applied to the first machine, was the utmost that could be expected

to be recovered at the second. From the data which Captain Griffin has laid before us tonight, we can see how great has been the increase in efficiency and economical results in the short space of ten years.

The President called upon Mr. Fred S. Pearson, Chief Engineer, Steam and Electric Departments, West End Street Railway of Boston, who in his remarks said that, as regards the efficiency of the electric cars in operation by the West End Street Railway Co., the electric cars are running with more certainty and are losing less trips than the horse cars.

THE PRESIDENT:—I would like to ask you. Mr. Pearson, if on the West End Railway there are any movements being made with regard to improving the motion of the car? I notice that there is a great deal of motion—is that due to the trucks or to the distribution of the load on the trucks?

MR. PEARSON:—I don't think that has anything to do with the electrical part of the equipment. You will find it about the same on horse cars when they get to teetering. Of course it is due to having a long car on short wheel trucks. Some experiments are being made in the way that Capt. Griffin has spoken of—getting an eight wheel car with two trucks. We had one out the other night testing it, and we are also trying the six wheel Robinson Radial Car. By having these two points of support, instead of one, we do away largely with that rocking motion; I imagine that in time an eight wheel or six wheel car will be adopted, because the road will then have a chance to use a longer car and carry more passengers with the motors which are used for propulsion.

CAPT. GRIFFIN:—I will say, Mr. President, in reference to that radial truck, we find it is exceedingly popular. There is no car on the West End Road that is so popular. I believe it was at the request of the people who live along the line that this car was put on the Chestnut Hill route. The motion is very smooth and there is no teetering. The only objection I have heard is in reference to the height of the steps—a mechanical objection that can be overcome.

THE PRESIDENT:—Did I understand you to say, Capt. Griffin, that a given wire was capable of carrying any voltage—that there was no definite relation, in other words, between the size or area of the wire and the voltage of the current.

CAPT. GRIFFIN:—What I said was that the size of the wire depends on the quantity of current and not the voltage. It is an actual fact that the Edison incandescent lighting current requires a very much larger wire than arc lighting current of 2,000 or 2,500 volts, although the Edison incandescent light only requires a current of 110 volts. It is the quantity of electricity which governs the size of the wire.

MR. J. A. TILDEN:—Capt. Griffin has touched lightly on the storage battery as one of the methods for the economical transmission of electrical force, and if it is not asking too much, I would like to inquire of him what is considered to be the commercial efficiency, to-day, of the storage battery—that is, its percentage of efficiency.

CAPT. GRIFFIN:—I should put efficiency of the storage battery at from seventy to seventy-five per cent. It is difficult to ascertain the average

commercial efficiency, because the different storage battery manufacturers claim almost everthing. I understand that there are very few who can not show factory tests ranging all the way from eighty-two per cent. up as high as ninety per cent.; but I have talked with a number of storage battery men, who seemed to be good, honest men, who have told me that there was no possibility and no use in talking of any efficiency of batteries in operation on a car, for instance, ranging above seventy per cent. I think it might be possible for stationary purposes, where the batteries are kept on racks and well taken care of, to have them run above that. The efficiency in such cases might possibly run as high as seventy-five or eighty per cent.; but I think that would certainly be the limit.

MR. J. P. FRIZZELL:—There is another point in connection with storage batteries, I think, which is of more importance than the one alluded to. I would like to ask how much weight of metal would have to be transported to secure a horse power, for a day, for instance, with storage battery.

CAPT. GRIFFIN:—I don't think I could answer that question without entering into a little calculation. The average storage battery weighs, I think, from thirty to forty pounds per cell. One hundred to one hundred and twenty cells, such as would be used on a car, would weigh from three to five thousand pounds—say two tons. That number of batteries would give you charge enough to carry a car, probably, for twenty to forty miles, depending on the conditions.

MR. TILDEN:—One word more. I have broached the subject of storage batteries because I feel, perhaps, that it may be a somewhat popular sentiment that the overhead system is but a temporary expedient and that the storage battery, when it shall have been improved will ultimately take its place. Of course the cars which are provided with motors to-day, could as I understand, be supplied by storage batteries, provided they were economical and efficient. I have asked Capt. Griffin a question in reference to the efficiency of the storage battery to-day, for the purpose of getting an honest answer on the subject. I understand him now to say that the dynamo gives about ninety-eight per cent. of efficiency.

CAPT. GRIFFIN:—Ninety-two per cent. efficiency.

MR. TILDEN:—And that the storage battery would give seventy-five per cent. of the ninety-two.

CAPT. GRIFFIN:—It might give seventy-five per cent.

MR. TILDEN:—And then the reconversion into power would be what per cent. of that?

CAPT. GRIFFIN:—Well, of course there is a loss in conversion. Our motors show an actual efficiency, by test, of about 91½ per cent. The commercial efficiency of the motors and gearing would not be less than seventy-five per cent.

MR. TILDEN:—You have ninety-two per cent. to start with and you get seventy-five per cent. of that in conversion into the storage battery. Then seventy-five per cent. of the remainder is converted into work in propelling the car.

CAPT. GRIFFIN:—Yes sir, that is about it.

MR. TILDEN:—Of course, the overhead system gives a much higher percentage of efficiency now.

CAPT. GRIFFIN:—Yes, it gives a much higher efficiency than that. I think the troubles with the storage battery at the present time are lack of durability, the weight which you have to carry on the car, and, more particularly, the limited amount of power we can store in the battery. That is, the car being limited in the amonnt of power which it carries, we are unable to overcome the unusual conditions that may be encountered at any time. A storage battery car could not possibly have battled with the snow as the motor cars have had to do this winter. A storage battery car, near the end of its run, when, perhaps, the current is pretty well exhausted, meeting another car that was disabled and attempting to tow it home would soon be used up. If a third car should come along and try to push the two home, it would be used up in turn. There are many important advantages which the overhead system has over the storage battery; but there is no question that the storage battery system is the ideal system. As soon as the present chaotic condition of patents is fixed—the patent question is a very serious one for storage batteries now, because no one knows where they stand—the storage battery will be rapidly developed.

MR. C. F. ALLEN:—I would like to ask one further question in reference to the storage battery. Has it been found possible to use the storage battery with cars already constructed for ordinary use as horse cars, or is it necessary, for the successful use of the storage battery, to have a car especially constructed for the purpose?

CAPT. GRIFFIN:—I believe they find it necessary to construct cars especially for the purpose. I suppose, of course, that an ordinary street car could be remodelled so as to give the desired space in which to put the cells under the seats; but, as the matter stands, it is not a simple question of remodelling the car, and I believe in most instances they have preferred to build new cars. Such is the case, at least, on the Fourth Avenue Line, where storage battery traction has perhaps been carried to a greater extent than on any other road. They have there ten cars in operation at one time; all new cars, constructed especially for that system.

MR. F. W. HODGDON:—That two tons weight of storage batteries be in excess of the ordinary weight of the car.

CAPT. GRIFFIN:—Exactly.

MR. HODGDON:—What is the ordinary weight of a motor car now?

CAPT. GRIFFIN:—The weight of the motor truck, with two fifteen horse power motors, such as are used here, is 7,200 pounds. and the total weight of the car would probably be 12,000 pounds.

MR. HODGDON:—How much would be the weight of the motor car over the ordinary car?

CAPT. GRIFFIN—I think the ordinary car would not weigh over five or six thousand pounds. Mr. Pearson, do you know the weight of the ordinary horse car?

MR. PEARSON:—I believe it is 4,500 pounds.

CAPT. GRIFFIN:—I mean with the wheels, axles and truck complete.

MR. PEARSON:—I couldn't answer the question exactly. The weight of the electric is about double that of an ordinary car.

MR. L. F. RICE:—Does the body of the car differ from an electric car?

MR. PEARSON:—Not at all. It is the same car body. We are using on the West End Road as electric cars, especially on the Cambridge line, a good many cars which were run as horse cars before.

THE PRESIDENT:—In transmitting power from some central source to a great distance, would it be practical by a high voltage to send a large quantity on a small wire?

CAPT. GRIFFIN:—In transmitting electricity over a very long distance if the voltage is high the wire may be small. The cost of copper increases in a geometrical ratio, so that it is a very essential that the voltage should be high if the distance be long, and the quantity of electricity to be transmitted is considerable.

THE PRESIDENT—Would you look forward to the time when electricity will be transmitted from some natural source, like Niagara Falls, to an immense distance.

CAPT. GRIFFIN:—It is perfectly feasible to do that now, but whether it will ever be done practically is a different question to answer.

THE PRESIDENT:—It seems as if, when the cost of the plant itself was so small and the cost of wires so small compared with the amount of power transmitted, that it could be done. The friction loss is very small, is it not, per mile?

CAPT. GRIFFIN:—Yes, if you have copper enough you can keep down the loss to any desired limit. The only serious difficulty would be that with an exceedingly high voltage, such as you might use, the question of insulation would be a very serious one. If you put your wires underground it would be very difficult to insulate them. Air insulation would be the best under the circumstances, but wires carrying a ten thousand volt current would be dangerous.

THE PRESIDENT:—Well, dry air is the best non-conductor, is it not?

CAPT. GRIFFIN:—It is the best.

THE PRESIDENT:—That being the case, if it were protected against wet from the top, and simply exposed to the air, it seems as if there would not be a great deal of loss.

CAPT. GRIFFIN:—Oh no, I think it would be perfectly feasible to so construct your line that the loss would not be a matter of serious moment —either by ordinary leakage at the different points or joints where it is supported, or the loss by insulation, or lack of insulation.

MR. TILDEN:—May I ask how many amperes of current the wires as ordinarily constructed for electrical purposes carry.

CAPT. GRIFFIN:—The average current for each car is about 10 amperes. I do not remember the limit of capacity of the No. 0 wire we use for the overhead wire, but it is never called upon to do its utmost. The feeder wires carry the current to the overhead wire at different points.

MR. TILDEN:—Then the electro-motive force is 500 volts, and 10 amperes per car?

CAPT. GRIFFIN:—Yes, sir.

MR. TILDEN:—I was leading up to the question which has been brought to my attention as to whether the safety of electrical currents is one of voltage only—that is, whether it is a fact that 500 volts at 10 amperes is not less dangerous than the same voltage carrying ten times that quantity for instance.

CAPT. GRIFFIN:—In one sense it is a question of voltage only and in another sense it is a question of both volts and amperes. A 500 volt current will drive a certain number of amperes through a given resistance. I might put it in this way, that $C=\frac{E}{R}$ (the fundamental electrical formula.) Now, if you substitute 500 for E, the electro-motive force, that is, fix the current at 500 volts, the amount of current (C) depends on the resistance (R.) The resistance of a human being is, say 2,000 volts so C in that case equals $^{500}/_{2000}$ or one-fourth of an ampere. Which means that a 500 volt current will drive one-fourth of an ampere through a resistance of 2,000 ohms—that is, the human body—and that is as much as it will drive. It does'nt make any difference how much more current there may be in the wire you touch, when you have received one-fourth of an ampere you have gone as far as you can, and if there are forty amperes, four hundred amperes or four thousand or four million amperes in that wire, it doesn't make any difference. When you touch it, the 500 volts can just drive a quarter of an ampere through you. To illustrate, you might regard that as a big water pipe and whenever you tap it and put in an inch pipe just so much water will come through the inch pipe. It makes no difference whether the large pipe is three inches, three feet or three miles in diameter, so much will come through that one inch pipe. So in the former case, the question of danger is simply a question of voltage.

MR. TILDEN:—That is because the resistance of the human body is so high?

GAPT. GRIFFIN:—Yes, sir.

MR. TILDEN:—If, on the other hand the resistance of the human body was low and you could get 50 amperes through, of course it would be safe to take ten?

MR. GRIFFIN:—Yes. sir. The question of amperes comes in when you take a very high voltage. Prof. Thomson states that he actually took a 10,000 volt current. It was simply a brushing contact, but he says he had time enough for the sensation to go to his mind and for him to reason with himself, "Now, old fellow, you are done for if you don't get your hand away from there," and he did get his hand away. It was a very small current, very feeble, as regards the number of amperes—but with a tremendous voltage.

MR. TILDEN:—Very much less than a quarter of an ampere, I suppose.

CAPT. GRIFFIN:—There is no question but what 10,000 volts would be able to drive enough amperes through the human body to kill half a dozen people; but it was either the feebleness of the contact or the very small quantity of electricity there was in the current, that saved him.

MR. TILDEN:—You have made a very interesting comparison with a water main there. We will compare, then, the volt directly to the pres-

sure and the amperes to quantity. That is, take, for instance, a pipe that has 500 pounds pressure is comparable to a wire carrying 500 volts—one that is capable, we will say, of supplying so many gallons of water, perhaps, per minute, would be in the case of a wire so many amperes.

CAPT. GRIFFIN:—Exactly, and that comparison will hold good still further, because if you increase the pressure in the pipe, you increase the quantity that goes through the one inch pipe. A pressure of 500 pounds to the square inch will drive more water through the one inch pipe than a pressure of 100 pounds to the square inch—so a voltage of 2,000 will drive more amperes though the human body than a voltage of 500. In fact, the comparison will hold good all the way through, and, now that it occurs to me, I might give you an illustration of how that comparison may sometimes be used. I was called before the District Committee of the United States Senate in reference to the railway that I have referred to. Senator Edmunds was suddenly aroused to the fact that dangerous wires were going up along that railroad and introduced a resolution requesting the commissioners to revoke the permits that they had given. I went to see Senator Edmunds, met him in the Committee room, and had an interesting conversation with him. I talked two hours and a half with him and I think I made some impression, for he has never discussed the subject of electricity in the Senate since. I, at least, convinced him that there was a great deal about electricity that he didn't know. He asked about insulation and spoke about the current used on the wire. He said, "you have a 500 volt dynamo?" I said "Yes." "What are you going to do when you want more cars on that line?" "Put in another dynamo." "Another 500 volt dynamo?" "Yes, sir." "And use the same wire?" "Yes, sir." "Then you will have a 1,000 volt current?" "No, we will have the same current that we had before." He said, "I wish you would explain that theory of yours to me." I said, "It is not a theory of mine, Senator, it is a scientific fact. I will illustrate it in this way: suppose you have a reservoir here containing 95 per cent. alcohol, connected with this pipe (pointing), and suppose you have another reservoir containing 95 per cent. alcohol here, and you connect this with the same pipe. When the currents come together we do not have 190 per cent. alcohol. It is the same 95 per cent. alcohol, but there is twice as much of it flowing as before. It is the same here, with the electric current, we have the same 500 volt current, only there is twice as much of it flowing. The pressure of the alcohol in the pipe depends upon whether you put the second reservoir above the first, or alongside of the first. If you put it on top of the first you will get double the pressure with the same quantity, and if you put it alongside the first, you will have the same pressure but double the quantity."

MR. FRED. BROOKS: A little while ago, in speaking in connection with the power house at Allston, you spoke about the transmission of electricity for long distances—what did you mean by long distances?

CAPT. GRIFFIN: Say anything above five miles. "Long" is a very indefinite term. I believe the distance from the power house at Allston to the extreme end of the Arlington line is about six miles—fully six miles.

MR. BROOKS:—Speaking of long distances, you mean longer than that?

CAPT. GRIFFIN:—Yes, say ten miles. Of course the limit of economical transmission of electricity would depend entirely on the circumstances of the case. If you had water power and could build a dam very cheaply and get power for almost nothing after your first cost, you could afford to transport it a very long distance—perhaps ten or fifteen miles, or even longer than that.

MR. RICE:—In your opinion, would it ever be advisable to extend your definition of length in the same manner in which that definition relates to long distance telephones—so that your electric current could be transmitted 500 or 600 miles, instead of five or six miles only? Would you consider it a feasible thing to ever transmit power for that distance?

CAPT. GRIFFIN:—Five or six hundred miles is a very long distance.

MR. RICE:—Of course it is. For instance, take Niagara Falls. Could the power from those falls be utilized in New York City?

CAPT. GRIFFIN:—I say now that it is possible to do that whether it would ever be advisable or feasible to do it is a very difficult question to answer. I should not want to answer that question. I can only say that it is perfectly possible to do it, but I doubt if the time will ever come when it is practicable to do it.

MR. RICE:—What I wanted to get at was whether you could see far enough ahead to give an answer to that.

CAPT. GRIFFIN:—As I say, it could be done to-day, but the expense would probably be too great to make it desirable as a good, commercial investment.

THE PRESIDENT:—It amounts to a difference between the scientific and the commercial side.

CAPT. GRIFFIN:—Yes, that is where the question really comes.

MR. A. H. HOWLAND:—I suppose, if copper was two cents a pound that it would make a vast difference as to the feasibility of doing it?

CAPT. GRIFFIN:—Yes, it would make a good deal of difference, it would make a very great difference.

MR. TILDEN:—I understand that for the transmission of power for long distances it is desirable to use very high potential alternating currents, or it is contemplated to use such currents, with the idea of getting a small wire—am I correctly informed?

CAPT. GRIFFIN:—No, not necessarily alternating. In fact, the alternating current as we stand at present, could not well be used, because we have no satisfactory form of alternating motor. It would be a high potential current, but would probably be a direct current.

MR. TILDEN:—The question I was going to lead up to, if the question was answered in the affirmative, was whether the efficiency of the converters is high or not—that is, for the converting of a high potential alternating current into a low potential current and large quantity.

CAPT. GRIFFIN:—I don't know exactly what the efficiency of the converters is, but am under the impression that it ranges from 80 per cent. up to 90 per cent. They have been very much improved over the earlier

forms and the results now obtained are very satisfactory. I spoke of transmission by the alternating current, where that could be used directly. For instance, you could furnish incandescent lights for houses by a power six, eight or ten miles away, could transmit that power in the shape of a two or three thousand volt alternating current, and transform it at the city limits, or some convenient point, to the low potential wire on which you want to use it. But for power and mechanical purposes, in the present state of the science, the alternating current would not be so satisfactory as the direct current.

MR. TILDEN:—The direct current can be reduced from a high potential and a low quantity, to a low potential and high quantity?

CAPT. GRIFFIN:—Yes, sir.

MR. TILDEN:—By converters?

CAPT. GRIFFIN:—No, there are no direct current converters. It would have to be done by the interposition of a motor or some multiple system. The case I cited was a case where you would establish a station and utilize the high potential current to run a motor or motors. These motors would run a line of shafting to which would be belted the incandescent dynamos, arc light dynamos and power motors, for any of the different circuits we now have in the city. This is not an economical method of transporting power, but I think it will be found, under some circumstances, to be more economical than to use the power direct from the steam engine.

THE PRESIDENT:—I suppose one of the most important things for the public to know in regard to the use of electricity for railways is how far their safety is assured in the event of accident. I saw it stated not long ago, that in case of certain brake rods breaking on electric cars, it would be possible for the people in the cars to receive the charge of electricity.

CAPT. GRIFFIN:—That is not so. I can hardly conceive a case where that would be possible. It might be possible for the brake rods to break in such a way as to form a connection between the motor and the break handle, so that, if the wheels were insulated from the rail, or partially insulated, one might receive a little shock by taking hold of the brake handle and standing on the ground. But it would only be a shunt that would go through the body, very small in proportion to the amount that would go through the wheels, and that is probably such a forced case that you can hardly consider it as at all probable. On the other hand, your question brings up a very practical question, and that is, if the brake rods break or the brake mechanism breaks when a car is going down hill, what are you going to do? You can stop it by the electric motor, reversing the motor and catching the car. That has been frequently done. I saw a car that was coming into Harvard Square—I suppose it was going at the rate of four or five miles an hour—and as it approached Harvard Square the horses on a horse car standing on the outgoing track became frightened at something and sprang across the other track directly in front of the electric car. The driver immediately reversed the motor. There was a tow car behind the electric car, and the iron rod connecting the two cars was bent in the shape of the letter U. It was an iron rod, one

inch in diameter, and the sudden stop of the car, with the other car coming on behind, bent the rod. But the cars were stopped all right, and no injury was done to the horses, except that the first horse was knocked down. Neither of the horses were injured.

MR. A. W. LOCKE:—I would like to ask Capt. Griffin whether there is any more adhesion in a car run by electricity than there would be in a car propelled by steam.

CAPT. GRIFFIN:—I would say, in answer, that it has been claimed and is claimed now, that there is, in the passage of the current from the wheel to the rail, a very considerable increase obtained in the way of adhesion to the rail. I have never verified this by any experiments of my own, although I have intended to do so, and have made arrangements on numerous occasions to do so at our factory in Lynn. But I know that, under other circumstances for instance, the road at Pittsburgh or Allegheny City, where they claim a 12½ per cent. grade, and where they used a conduit—where there is no current passing from the wheel to the rail—they have sufficient adhesion to overcome heavy grades without any auxiliary influence of that kind to help. A great many people, and many eminent men claim that there is an actual increase in adhesive power due to the passage of the current.

MR. ALLEN:—There is one question I would like to ask. I simply ask it for the purpose of bringing out a point. It has been stated to me by some electric railroad men that in running down hill the motor can be used in such a way, where the grade is sufficiently steep, as to act as a generator, and I think it would be interesting to ask Capt. Griffin his ideas upon that point.

CAPT. GRIFFIN:—That is a fact. The motor, of course, is the same as a generator and acts as a generator running not only down hill but all the time. The motor is a generator and the current generated by the motor is a reversed current, in the opposite direction to that generated by the generator, giving us what we call the counter electro-motive force. The counter electro-motive force increases as the revolutions of the armature of the motor increase, and counteracts the electro-motive force of the dynamo. It has been suggested that when the car is going down hill you break the connection with the overhead wire and connect the motor with a storage battery, placed under the seat or somewhere in the car, and so utilize the power of the motor as a generator to charge the storage batteries. Several patents have been taken out on this idea. It is perfectly feasible on paper. It is theoretically unobjectionable, but practically it would never do, because it would introduce many complications, and the advantages gained by it would be very slight, if any.

MR. ALLEN:—I rather had the idea, from what was stated to me, that it was claimed that in running down hill the motor could be used in such a way as to return a certain amount of current to the dynamo rather than to use a certain amount.

CAPT. GRIFFIN:—I don't think that could be, because the current generated by the motor is in the reverse direction from the current which comes out from the generator— the overhead wire.

MR. ALLEN:—I didn't myself think that anything of the sort could readily be done, but I spoke of it simply to bring out the point and to get information.

CAPT. GRIFFIN:---I doubt if it could be done. because one pole is attached to the ground and the other to the overhead wire, and that would practically be a short circuit with the overhead line. The great difference in quantity between the current generated by the dynamo and that generated by the motor would be such that the current from the dynamo would simply rush down through the motor. It would not be practicable.

MR. TILDEN:—That is, the dynamo would have to furnish a greater voltage—or the motor would have to furnish a greater voltage in order to get electricity back into the wire.

CAPT. GRIFFIN:—Yes sir. The moment you make the connection unless you drive up a greater current than the generator is trying to drive down, the current coming down will run through it, and unless you generate a current greater than 500 volts nothing is accomplished. It is just the same as the illustration in regard to water. Unless you can get a greater pressure working upward than downward, the water will simply run back through the pump.

MR. HOWLAND:—Speaking of Allegheny, I understand there is a rack rail used in connection with the road there.

CAPT. GRIFFIN:—I have understood that that has been taken off since. At first I was informed that it was used during the winter and taken off during the summer, but I have since been informed that it has been taken off entirely. At first it was considered indispensable, but the road has been operated without it and, I think, for some time.

MR. R. A. HALE:—In the transmission of power for mechanical purposes, what percentage of loss would you count on per mile, in a well arranged system—that is, supposing you had a water wheel?

CAPT. GRIFFIN:—I should put the percentage of loss in the generator ---that is, the loss in the power that the wheel applies to the generator--- at 8 per cent. The loss in the line is something you can regulate yourself. It depends entirely on the amount of copper used in the line. You can construct a cheap line, using little copper, and have 50 per cent. loss, or as much as you choose, or you can put so much copper into the line that the loss will be only five or ten per cent. As I have stated, the economical point is where the interest on the investment in copper is just equal to the cost of producing the power wasted. That evidently would be the most economical point, for one element or the other increases as you recede from that neutral point.

MR. HALE:—Five per cent. would probably be the minimum of loss?

CAPT. GRIFFIN—I think generally ten per cent., except in case of short distances. Of course it is a question of mileage and the cost increases in proportion to the amount of copper used.

MR. HOWLAND:—In case of an elevated road, where would you put the wire?

CAPT. GRIFFIN:—There are several suggestions made in reference to that. Mr. E. Moody Boynton's bicycle railway is specially adapted to elec-

tric railway purposes. He has an overhead structure in the shape of an oval like this (illustrating) with two vertical wheels, or wheels on vertical axis running there (illustrating) to prevent the car from tipping sideways, and only having a single rail here. Now the out-going and incoming conductors can be placed here and the wheels will perform the function of collectors, taking the current through the motor and back. In the case of the ordinary road where we have two rails, we can place a third rail here (pointing) and take the current from this rail. The current would come from the generator through the insulated third rail and return through the other two. I don't think overhead wires would be necessary with an elevated road. Owning the whole structure, all details can be arranged to the end in view.

MR. TILDEN:—Just that arrangement was tried on the 32d street line, was it not, with the third rail?

CAPT. GRIFFIN:—Yes sir. It was a question of the motor there. They used an electric locomotive. So far as I can see at the present time, it would be better to apply a motor to each of the cars. The trucks are so readily removed and replaced that I think it would be a very small matter to do it. Each car would have its own power, and if you wanted a six, seven or eight car train, you could have it. It would greatly facilitate the switching arrangements at the car house to have each car able to go where you wanted it to go. Each car could take care of itself.

MR. TILDEN:—The mistake in New York was made in trying to put too much power into the electric motor.

CAPT. GRIFFIN:—Yes sir. They tried to build too large motors.

MR. A. L. PLIMPTON:—Can it be easily arranged so that the driver of one car can manage all the motors at the same time?

CAPT. GRIFFIN:—Yes sir. We now have connections between the motors and the tow car, to light the tow car. On many of the roads the tow cars are lighted by electricity and arrangements to carry the current are easily made. I don't think we could use resistance coils. We would require some different arrangement from what we now use. We are about to try a regulating device, which will do away with a great deal of complication. It would not be practical to use our present method because we could only use one rheostat, and if we had one large enough for an eight car train it would be too large for an individual car. Otherwise it could be done.

JAMES B. EADS.

BY E. L. CORTTELL, MEMBER WESTERN SOCIETY OF ENGINEERS.

[Read June 4, 1890.]

On the resolution to co-operate in erecting a statue to the late James B. Eads.

A proposition to erect a monument to the memory of any man should have careful consideration. The instances, however, are not rare where exceptional usefulness to mankind has been rewarded by monuments and statues. Civil and military heroes, who have achieved greatness through victories of peace and war, have been thus honored; but rarely is there seen anywhere in the civilized world a monument to the Civil Engineer, however great may have been the victories on the broad field of constructive commercial works, or however important their results to man. Why should the world not honor the engineer who may have accomplished important works for commerce? Why should it not express in befitting form its appreciation of and respect for an engineer to whom it may be indebted in the line of civil, mechanical or military engineering?

It was but as yesterday that we laid in restful Bellefontaine, overlooking the great Mississippi, on which and in which he almost spent his life, a Civil Engineer whose fame had already gone into all the world. Let us see whether, as an engineer, he is worthy of the great honor which it is now proposed to bestow upon him. Let us rapidly sketch the life, delineate the character, recount a few of his engineering deeds, outline his works left incomplete—taken away while yet in the prime of his usefulness—and then draw our conclusions of his merit and decide whether he is entitled to so great an honor.

In the year 1833, when 13 years of age, James B. Eads landed with his family, homeless and almost without the means of support, at the very place where he afterwards built one of the finest engineering structures the world has ever seen to this day. Unable to obtain the higher education, now open to any lad who desires it, he worked in the store in the day time as a clerk and in the night as a student in the library of his employer. The passion of engineering was in his soul even then, for it is recorded that he built a real steamboat about six feet long with its real boilers, engines and all the necessary appurtenances for its movement in the water, and navigated it on the waters of Choteau Pond, where now is Fourteenth street, St. Louis.

He began his study of the Mississippi River at the early age of 18, for while purser of a steamboat he studied out how to remove the wrecks that in those days were strewed along the river from its source, almost to the Gulf. He was only 22 years old when he built a diving-bell boat for recovering cargoes, and soon after fitted a larger boat with lifting appliances,

by which he raised large steamboats cargoes and all. He, himself, invented and directed the construction of the many appliances required for this difficult, hazardous, but useful work; not only that, he superintended the work himself and often went down in the diving-bell into dangerous and exposed places where his men were unwilling to go. He was no great, robust man, full of physical strength, but a small slender man cast in a delicate mold, but yet he was endowed with remarkable endurance and a courage both physical and moral, that never quailed, and was never daunted in the presence of the greatest perils; he never lost his self-possession. Nearly 14 years of his life were thus spent on or in the great river and its tributaries. In this business he gained an experience and a knowledge of the currents, sediment, and the many peculiar conditions of the river and its tributaries that was of immense value to him and to the world, in designing and building the commercial works that made him famous. This was his school, his university. Graduated from it at 40, he was able then to cope with the stupendous problems almost continually thrust upon him until the time of his death at the age of 67.

First the terrible war and the enginery demanded to meet the extraordinary conditions that suddenly arose before the people. This period of four years was one of almost superhuman exertion in the line of naval warfare for this young man. The administration laid upon his shoulders what would have crushed a man of less genius or self reliance. Think for a moment of a man agreeing to construct seven 600-ton iron clads with iron plating 2½ inches thick, with a heavy armament, in sixty-five days. That too at a time when the foundries, forges, rolling mills, saw mills and machine shops were idle—shut up – the mechanics all gone, or going, to the war; in a border state where the peaceful arts were suspended and internal dissensions rife were on every hand; that, too, when the materials themselves of which the boats were to be built were in the forests still, and in the ore, and the great plate rollers had not been built.

But the papers had hardly been signed at Washington when this man started by telegraph the lumbermen and the saw mills in seven different States and pressed into service railroads, steamboats and barges for the transportation of the timber to St. Louis. The largest foundries and machine shops in St. Louis, Pittsburg and Cincinnati were crowded with his work, and for hours at a time he crowded the telegraph lines with his detailed orders and directions here, there and everywhere, in building the 21 steam engines and 35 steam boilers for propelling his fleet. The rolling mills at Portsmouth, Ohio, and Newport, Ky., and at St. Louis were employed in rolling the armor plate. Within two weeks from the time the papers were signed 4,000 men were at work on the fleet. An eighth iron clad was added and, says the historian, of our navy: "Thus one individual put in construction and pushed to completion within one hundred days a powerful squadron of eight steamers, aggregating 5,000 tons, capable of steaming at nine knots per hour, each heavily armored, fully equipped, and all ready for their armament of one hundred and seven large guns. The fact that such a work was done is nobler praise than any that can be bestowed by words."

We sketch these details that the wonderful executive ability of this quiet unassuming engineer may be appreciated. Fourteen in all of these heavy iron clads were built, rapidly following each other. Seven transports were made musket proof gun boats and four heavy mortar boats were launched and equipped. Without this fleet, designed, built and equipped by this engineer, it is doubtful if the war would have been so soon ended, for the Mississippi River could not have been opened and kept open, and the lines of the enemy could not have been broken through. Such men deserve a place beside those who won great naval or land victories.

But. "Peace hath her victories no less renowned than war," and with the dawn of the day of peace there came upon the engineer the problem of bridging the great river upon which his life had been thus far spent. This grand, beautiful and eminently useful commercial work of his brain and hand needs no encomiums from us engineers; we simply point to it as a great pioneer in the art of sinking deep foundations and building spans over wide stretches of space, that astonished in its construction at that time the entire civilized world. It was without precedent in the depth of its foundation, the length of its spans and the great difficulties attendant upon its construction in such a river with its strong currents and shifting sands. The super-structure of this work marks an era in bridge building, and particularly in the character of materials. How great an impression this work made upon the world may be seen from an article from *London Engineering* written during the time of the construction of this bridge: "Our present requirement being to select some example of the most highly developed type of bridge building of the present day, we have no difficulty in passing before ourselves in mental review the different works now in progress throughout the world. and we have still less difficulty in selecting as our example the magnificent arched bridge now almost completed by Captain Eads at St. Louis. In that work the alliance between the theorist and the practical man is complete. The highest powers of modern analysis have been called into requisition for the determination of the strains; the resources of the manufacturer have been taxed to the utmost in production of material and perfection of workmanship; and the ingenuity of the builder has been alike taxed to put the unprecedented mass into place. In short, brain-power has been called into action in every department. One longsighed for result, the welding of the theoretical and practical man into one homogeneous mass, without which no truly great undertaking could possibly be carried out, has at last been attained."

But this Civil Engineer had before him greater works than these. Not satisfied with binding the East and West together by this link across the Mississippi River, his thoughts and his heart turned towards the cherished desire of his early life—the opening of the mouth of the river for the commerce of the great valley—thus breaking down the barrier lying stolidly between it and the great world beyond. The long, arduous struggle of the engineer to accomplish this great purpose needs no recounting to this society. It and its grand results are cherished in the memory not

only of all engineers in the world everywhere, but of the millions who make their home in the immense territory whose commercial prosperity was so greatly enhanced by his work. The papers on this subject which came from his pen and the addresses which came from his lips would alone entitle him to the great respect of his fellow men. They were unsurpassed in value, as engineering expositions, illustrating, describing and elucidating so plainly, that all could understand, those occult, but potent principles that control the flow of water, the movement of sedimentary matter and the correct methods of river and harbor improvements. In the minds of those who were associated with this engineer in this great work the impressions of the man are indelibly traced. Whatever of discouragement may at any time have taken possession of them it is absolutely certain that no obstacle of an engineering, financial or any other kind ever for a moment disturbed or discouraged him. His complete knowledge of the conditions and the forces he was dealing with gave him unfaltering faith in the plans of the work, and yet there was something more than knowledge. There was genius of the highest order that gave to him unalterable determination to achieve abundant success and a sublime faith in what he always believed were the clearly written laws of the Creator. An elevated purpose, almost heroic in its outcome under nearly insuperable difficulties, marked all his path during the progress of this work. From beginning to ending, from the universal doubt that prevailed all over the land in the success of his work to the grand final achievement, he never deviated from the path laid down at the inception of the enterprise, when in words almost prophetic he said: "I therefore undertake the work with a faith based upon the ever-constant ordinances of God himself; and so certain as He will spare my life and faculties for two years more, I will give to the Mississippi River through His grace, and by the application of His laws, a deep, open, safe and permanent outlet to the sea."

The success of this important undertaking for the benefit of commerce, the continued maintenance of the deep channel obtained by the works, the confessedly difficult engineering problem successfully solved, and the commercial importance of the work to the civilized world; all serve to place the engineer who proposed, designed and built the Mississippi Jetties in the forefront of Hydraulic Engineers and among the great benefactors of the race.

His life was full of unselfish patriotism and desire to promote the welfare of his fellow men everywhere. In nothing is this seen more than in his unremitting efforts to secure the improvement of the Mississippi River between Cairo and the Gulf of Mexico. The statement will go unchallenged that he not only did more than any other man to bring about systematic plans of river improvement, but that, without him, the work would not have been undertaken by the United States Government, certainly not at that time. None but his intimate friends, in and out of Congress, know how much the country is indebted to him, or know that by his untiring efforts there was put into execution one of the most comprehensive plans of river improvement ever conceived of in the civilized

world; or know that the public sentiment of the country was enlightened and brought to the point of action by his written expositions, addresses to Congress, communications to magazines and newspapers, published pamphlets and by public addresses. The improvement of the great river and the welfare of its millions of people were the cherished objects of his life. Woe be to the man, or men, who stood in the way as objectors to the instituting of correct plans, or who attempted to dissuade the country from adopting them. His discussions on important engineering questions under these circumstances often made him appear unrelenting, acrimonious, hostile and even bitter, but kindness of heart, even towards those who opposed him, were among the many noble qualities that marked this man of genius. Thus he worked assiduously for years to bring about the correct improvement of the Mississippi River. He had no selfish interest of any kind in it, and no thought of fame, or the honor of his countrymen, or of the world, ever for a moment gave any motive for his almost martyr-like work; for he was almost dragged from the scene of his labors in Washington by his physician, who peremptorily ordered him away to save his life—so feeble and sick unto death was he through his constant, absorbing work for the improvement of the river.

His greatest project, to which his last years full of weariness and pain were given so unstintedly, was one born of the noble desire to extend the commerce of the Mississippi River into the Pacific Ocean and the great countries upon its shores. The ripe intellect, the rich experience and the trained mental powers were unreservedly given to what he believed to be the grandest of all his works,—a work to him so great and so vast in its conception and in its possible results that he often appeared to be lifted to the spiritual plane, moved by a heaven-born purpose; and he said to his intimate friends: "I shall not die until I accomplish this work and see with my own eyes great ships pass from ocean to ocean over the land."

He was wont to recite with all the fervor of faith changed to fruition the prophetic words of the poet, who, with his minds eye saw the same sight:

> "Lo, ships, from seas by nature barred,
> Mount along ways by man prepared,
> Along far-stretching vales, whose streams
> Seek other seas, their canvass gleams;
> And busy towns grow up on coasts
> Thronged yesterday by airy ghosts."

When in a foreign country he was dying and was told that he could live but a little longer, the anguish of a great soul was felt by those around his bedside when he said, still firm and inflexible of purpose: "I cannot die. I have not finished my work." How passing strange are the mysterious acts of the Creator.

It would burden this sketch to even allude to the many important engineering works in this and foreign countries that occupied the time of this engineer; planning and examining harbor works in North and South America and in Europe; honored for his successful works in behalf of commerce by the presentation to him of the Albert Medal by the Society

of Arts of Great Britain (he being the first American upon whom this distinguished honor was bestowed) and in the following words: "*Resolved*, That the Albert Medal be awarded to Captain James Buchanan Eads, the distinguished American engineer, whose works have been of such great service in improving the water communications of North America, and have thereby rendered valuable aid to the commerce of the world."

This is the life—these are the works—of the Civil Engineer on whom the crowning honor is about to be bestowed by his countrymen; but as his countrymen were of all the civilized nations, this monument should be erected by all the world. Genius like this knows no bounds of land or ocean; no arbitrary limits can restrain it. It went forth and was felt, and will forever be felt, to the remotest boundaries of the civilized world, in ameliorating the conditions of commerce and industry, and through them of the human race.

A monument befitting this grand figure of the age—this world-renowned civil engineer—should be erected, overlooking the great river whose commerce was so dear to him, and for whose countless people he spent his energies and laid down his life.

THE WORLD'S COLUMBIAN EXPOSITION, CHICAGO.

Discussion on the Question of Site by Members of the Western Society of Engineers, September 3, 1890.

By Isham Randolph.

We have for our topic to-night a theme which rises above all local considerations, and passing beyond even national confines, enters the arena of the world's great interests. The World's Columbian Exposition needs a site. For many months this great enterprise has been tossed hither and thither upon the troubled waves of conflicting interests, and the bark that bears it has in metaphorical sense, breasted waves as fierce as those which beat upon the craft of the great explorer from whom it takes its name.

But our calling leads us to deal with facts, not metaphors; and it is our province to shape the forces which Almighty wisdom and power places within the scope of man's ability to master. We as engineers are invited to discuss the whole question of sites in or near Chicago. For myself I have elected to champion the cause of the Lake Front, the one locality whose claims of consideration have interested me and enlisted my active thought and research. In my conviction this is the ideal site, the spot for the gathering of the nations of the earth to behold an aggregation of the achievements wrought by each in the domains of architecture, science, art,

invention and mechanism, in all of its intricate and varied forms, such as human eyes have never before since the creation been called to gaze upon.

Its claims are briefly stated and may be well sustained. It is central to a degree which cannot be attained by any other site. No other locality is so accessible, and nowhere else can the vexed problems of transportation be so easily solved as here. Its entire frontage on the east commands a view of the one great boon which nature has given to Chicago, the grand and glorious lake, in the view of which centers all that is beautiful vouchsafed to this locality by the Creator unaided by human genius or human toil.

Many, in fact most, will admit its claims, but while admitting, ask the mighty question, Is it available? The answer to this question does not lie in the solution of any one of the aggregation of problems which vex the issue. There are legal problems but these are not for us to discuss, for I am like the judge of whom a noted lawyer said that he was like necessity, he "knows no law." Then there is the problem of the City Council. Where is the prophet that will declare to us that the city fathers will rise to the occasion and without fear or favor confer this boon upon the municipality; and by their act expand the lungs of the great metropolis; bringing health to her people and adding beauty and fame to her grand domain? Who will speak for the Michigan Ave. property holders and assure us that they can and will rise superior to selfish considerations and join hands with the forces working for the city's weal.

But these questions are not for us. What we are asked is the great question, "Is it practicable to do this mighty work and have it an accomplished fact in time for the uses of the World's Columbian Exposition?" Realizing its magnitude, deeply impressed with a sense of all the difficulties involved in carrying out this work of creating scores of acres, where now the restless waves are rolling fathoms deep, I most unhesitatingly, with a confidence based upon what man has done as a guaranty of what man can do, affirm that it can be done.

Before entering upon a discussion of details I wish to have you turn your eyes to the map which I have prepared to illustrate the situation. There you will see the water frontage of Chicago, from the Chicago river to 22d street. The yellow line indicates the shore or dock front of today. The green borders enclose the area available for the uses of the Exposition, and the red borders bound the areas asked for by the Illinois Central R. R. Co. The apportionment for the Exposition as you will see tabulated on the map comprises:

The Lake Front Park	29.00 acres.	
Right of way, shop grounds and yards surrendered by the Illinois Central	75.66 "	
Three blocks north of Monroe street	8.09 "	
Dearborn Park	1.40 "	
Total land new made		114.15 acres.
Area to be filled north of 13th street pier	133.50 acres.	
Area to be filled south of 13th street pier	41.35	
		174.85 "
Total acres available		289.00

In addition to this area, if more be demanded, piling and flooring can be successfully resorted to (but I am no advocate for that method of providing space), and the area, *A*, 56.74 acres, within the breakwater be created, and the area *B*, with the breakwater, 45.5 acres be added thereto. I have thrown into the plan, by way of suggestion, an interior lake, symmetrical in outline, because of the difficulty of working the lines of beauty with materials so rigid and stubborn as piles and square timbers, but I throw this suggestion in merely as a starting point from which revision and better work may begin. Having our areas, we next come to cubical contents. Assuming that the landscape architects will use up in miniature lakes and water courses an area equal to my lake (35.7 acres) the area remaining to be filled would be 139.2 acres.

From soundings taken by Mr. Artingstall we have the necessary data for calculating cubical contents north of Park Row, but south of that line we are left to conjecture as to depths. Therefore, I have had to assume an average depth, which I consider absolutely safe for the whole area. This depth, below a grade line of 5 feet above city datum I have taken as $16^{5}/_{10}$ feet; hence the total number of cubic yards to be put in place foot up 3,704,738. Can this vast pile of material be placed in time to meet all the requirements? Without a peradventure it can. I have gone carefully, I had almost said exhaustively, into this subject; I know where the magazines of supply are, what lines of transportation reach them, and what the capacity of those lines is for doing the work. The Baltimore & Ohio, the Lake Shore & Michigan Southern, and the Michigan Central stand ready to undertake the transportation of the material: and those three roads can make the entire fill without help from any other source in 250 days, allowing for detentions. Each road can, without hindrance to its regular traffic, deliver 400 cars per day upon the proposed site, making a total delivery per diem of 1,200 cars of 15 cubic yards each, or 18,000 cubic yards. I have discussed this matter with men of the ripest experience and most mature judgment in such matters, and with one accord they agree upon the practicability of the plan. Only yesterday Mr. John Newell, of the Lake Shore, told me, and authorized me to repeat it, that he would agree that his road should deliver one-half of the amount of the entire fill in 250 days if necessary.

Of course these deliveries are all predicated upon the setting apart by the Illinois Central Railroad of two tracks from the site of the fill to connect with the roads bringing in the material, and that they will do this I am well assured. So much for the land forces in this work. But while they are keeping up their end, the marine forces will be making their record as well, and the quota from the dredges will be tremendous. It is entirely within bounds to say that 15 dredges can and will be employed upon this work, and their output will average 1,000 cubic yards each, or 15,000 cubic yards every twenty-four hours. The combined land and marine forces can make that fill in 113 working days. Add to that 30 days for detention from all sources, and we get the fill made in 143 days.

As to the cost of this work I have such information as to details, such as cost of handling, transportation charges and other costs incidental to

the work, as justify me in declaring that 40 cents per cubic yard, or $1,482,000, is an outside figure for doing the entire work of filling. Mr. John Newell told me that he had told President Gage that the work could be done for that. But what better evidence can we ask from practical constructors of their belief in the practicability of doing this work on time and for a reasonable cost, than the fact that two of the oldest, most responsible and reliable firms in this city have affixed their names to a paper, which has been formally delivered to the Building and Site Committee, declaring their willingness to enter into a contract to do the work in 250 days for a sum closely approximating my estimate of cost.

It must be remembered that under the plan we are now considering there is no break water to be provided, unless the idea of filling and flooring be resorted to; in which case breakwater protection would have to be built. The only dockage that would be needed under this plan would be that along the shores of the interior lake and island, which, for the lake depicted, would require 11,150 lineal feet of dock front. Such a dock, owing to the depth of the water and the character of the material to be retained in place would be more expensive than the ordinary river docks, which cost anywhere from seven to ten dollars. I would assure the cost of this dock to be $14 per lineal foot, or $156,100, making the total outlay $1,638,100. It is scarcely necessary to remind such an audience as I have the privilege of addressing that the erection of the World's Fair buildings need not be delayed until the completion of this fill, for both departments of the work of preparing for the great event can be carried on at once.

Gentlemen, I thank you for your sufferance, and I trust that when the year 1893 rolls around we may stand together and gaze upon the grandest Exhibition earth has ever seen resting upon a broad base of acres which will forever remain a monument to Chicago's ability to grapple with grand achievements, and conquer, what the timid call, insuperable obstacles.

By Richard P. Morgan.

I have prepared a few words to say with respect to the World's Fair site. The subject is a very important one and any engineer who expresses an opinion ought to do so clearly. For that reason I have formulated a few words to express my opinion on the subject. As stated by the President, it has been under discussion for some months, and the different interests presenting the certain sites proposed have labored quite industriously to present the good and bad points of the several sites, so that we are pretty well informed, and to go over the ground in detail now would be like repeating a twice told tale. It is proper now for those who are familiar with the evidence that has already been given, to express their opinions briefly.

The question before the meeting this, evening, has been discussed in public and private for several months. The strong interest of those favoring the several sites proposed for the Exposition has fully developed the favorable and adverse consideration of each location.

To enter upon details at this hour would be to repeat a thrice told tale. It is proper now for those who are familiar with the evidences, to express opinions, briefly supported by the prime reasons for them.

Without other interest than to be sound in judgment, my mind is in perfect balance that the Garfield Park site has no equal in the contest.

1st.—It lies on the East and West axis of the city's population, and all things considered, is much easier of access for the people of Chicago and those who come to visit the Exposition than any other site proposed. Therefore, it insures the greatest financial success.

2nd.—Its natural conditions enable prompt, comprehensive and quick construction of perfect stability.

3rd.—Morally considered it is the most equitable site.

4th.—As to landscape, Mt. Shasta is not here; nor the picturesque coast of the Atlantic Seaboard, nor the beautiful hills, valleys and rivers of our neighboring states.

There is an extended unbroken plain, a city and a beautiful lake, the surface of which is almost on the same level with the plain. Every site proposed lies prone.

Beyond this some results of a minor character may be produced by landscape gardening. The grand effect must be in the buildings.

5th.—Incomparably the most complete picture of the World's Columbian Exposition could be perfected at Garfield Park. Raising the picture to view we have in the foreground the buildings and area of the Exposition; then the first intermediate is Chicago; the second intermediate is the Lake and all the effects that may be produced artificially upon it. The background is the sky bounded by the horizon. To the right and left stretch away the shores of the Lake finishing the only possible complete picture.

Turning to the west there is a view common to every site proposed. As far as aided eye can reach there is an area of country typical of the vast undeveloped empires which stretch away to the Pacific Coast, and of which it has been truly said "Here Nature has bared her bosom and invited the human family to come and partake of her choicest blessings."

By T. T. Johnston.

There are some sanitary and hydraulic attributes of the several sites proposed for the World's Fair which, as far as I know, have not yet been discussed. They pertain to the relations native population bears to the population that will be incidental to the Fair.

Any site at or near Jackson Park or at Washington Park necessarily lays on a piece of ground, the natural drainage of which is toward Lake Michigan. Consequently all surface drainage must go into the lake. Immediately north of these sites, extending southward from 12th street and eastward from State street, is a city area of some seven or eight square miles, the sewage, sewerage and drainage from which is all tributary to the Lake. According to the school census, which is accurate enough for the purpose, there lived 87,000 persons on this area in 1886 and

117,500 in 1890. The present rate of growth indicates that the resident population will be about 140,000 in 1893, and the sewage from all the people must go into the Lake, because the sewerage of the area now leads in that direction and there is no way in which it can be readily changed. Also the storm waters or drainage must certainly go into the Lake. The intake of the tunnel through which the township of Hyde Park is said to get a water supply and through which the township of Lake is said not to get a water supply is about one mile from shore directly east of Jackson Park. Very close to 150,000 people are thus supplied with water. It is very well established that no fixed currents exist in the lake. Sometimes no current exists, sometimes there is a northward flow along the shore and sometimes a southward flow. The net result is that the water at any time along the shore may at times swash back and forward without ever getting very far away. At other times there may be complete renewal of the water from distant points in a few hours or a few days. The sewage referred to above, especially when the sewers and streets are flushed by storms may or may not be carried in more or less undiluted shape to the water supply intake. At any rate the water supply is certainly jeopardized and doubtless is at times radically polluted. Many communities have expended much money to avoid far more remote danger of water supply contamination.

Dropping this line of thought for the present and looking southward about three miles from the water supply intake the community called South Chicago is found. In 1886 this comprised 12,000, and in 1890 it numbered 23,500 persons. In 1893 a population of 30,000 may be anticipated. The sewage and drainage of this community is not to be feared so much as that north of Jackson Park, still it is bad enough, and when northward currents tend to carry away the northern they bring on the southern sewage and drainage.

Intermediate between South Chicago and Jackson Park and a little to the westward is a community near Grand Crossing which in 1886 numbered 3,000 and in 1890 had grown to 13,500. In 1893 a population of 18.000 to 20,000 may be anticipated. These have no sewerage at present but their drainage goes to Lake Michigan and forms a minor but bad enough element in polluting the lake water. So much for the normal native population, which has, does and will environ the proposed Worlds Fair site and pollute the water-supply. It is summarized in the following table:

Source of Sewage and Drainage.	Population.		
	1886.	1890.	1893.
Northern.	87000	117500	140000
Southern.	12000	23500	30000
Total directly sewered.	99000	141000	170000
Intermediate.	3000	13500	20000
Total directly drained.	102000	154500	190000

How much is the sewage and drainage of this region likely to be increased by the presence of the Worlds Fair? Large numbers of people will become incidentally residents in the region either as employes or visitors to the fair. Large quantities of livestock will be continually present. Heavy travel of people and teams from the northward will add much to the normal amount of putrescible matter in the drainage northward from 12th street. Without going into details it will probably be safe to assume that the sewage and drainage thus created will at least equal the sewage and drainage from 100,000 or 150,000 people. At times worse and at times better. The result will be that the Hyde Park water supply intake will be about one mile from a shore along which the urban drainage of 300,000 or 350,000 people and the sewage of 270,000 or 320,000 people debouches. Can anyone doubt under such circumstances this water supply will be polluted and at times badly polluted? Is it not criminal thoughtlessness to so endanger the lives and health of the resident community and the visitors to the fair? It has come about that, in the so called legitimate pursuit of money, human life is too commonly sacrificed and it would seem that the Worlds Fair management are in danger of falling into line in this respect.

Some three or four miles northwest of the proposed sites exists perhaps the rankest cesspool that ever was. It is called the South Fork of the Chicago River. Its contents are usually of a pasty consistency rendering the passage of tug boats through it a matter of difficulty. Sometimes it catches fire—only a few days since this occurred and required the services of the fire department to extinguish the flames. No doctor would perform a surgical operation on its banks for fear of blood poisoning. It has been noted that the people living near it always seem to be healthy—and such is the case for only the healthiest kind of people can live near it. Those who are debilitated or predisposed to sickness do well to keep away from it. The census returns show that population does not accumulate near it. It is generally supposed that its condition is due to the sewage and drainage of the stock yards, which may not be so dangerous as an equal amount of filth from human beings. This is only in a measure true. The population tributary to it was 75,500 in 1886 and 147,000 in 1890. In 1893 the population will probably be increased to 200,000 or 225,000. The outflow from the South Fork is so slow that decomposition is to a great extent completed in it. Every northwest wind will bear its polluted atmosphere to the Worlds Fair, together with the vigorous and self asserting odors.

Southward from the sites proposed is a marsh full of bull-frogs and mosquitos and the alleged commercial facilities which are said to exist about Lake Calumet.

The sanitary conditions attending these sites can hardly be said to be good. The prospect of a polluted water supply and generally polluted atmosphere are not very encouraging.

If the fair or part of it be placed on the Lake Front, there will still be the same sewage going into the lake and nearly the same drainage. The sewage from the fair will be simply transferred from the southern end to the northern end of the urban area tributary to the lake. The Hyde Park

and Town of Lake water supply will not be so seriously menaced—the pollution of water supply will be more equally divided between the city and the southern intakes. Everybody will get some of it, except possibly the Lake View folks.

The North Side shore site has some advantages over its southern competitors. If the Worlds Fair sewage is disposed of in the lake then, it will be by itself to a great extent. It will be so remote from the southern sewage that the dangers will be reduced. They will be present nevertheless but will be divided up among all the water supply intakes. It is practicable, however, by the aid of pumping and gravity to dispose of the sewage through the Lake View sewers into the North Branch of the Chicago river, thus leaving only surface drainage to go into the lake. Comparatively few people on the North Side drain into the lake.

The West Side site offer facilities for sewage disposition by gravity without complications with existing population. In this respect it is probably the best of the sites proposed. It is not so remote from sources of atmospheric pollution as the North Side site, it being immediately north and west from the city sewage channels.

The hydraulic features of the several sites do not present such difficulties as the sanitary features. The southern sites are close to the water tunnel. An independent pumping and pipe system is a simple matter and water abundant but polluted.

The Lake Front site would necessarily take its water supply from city sources and could probably be supplied without much inconvenience to neighboring consumers.

The North Side shore site is at the Lake View tunnel and so close to it that the opportunities for water supply are much better than at any other sites, especially with regard to quantity of water.

The water supply for the West Side sites is a more serious matter. They are on strictly suburban area some miles from the nearest pumping station, with no existing pipe system adequate for the purpose. Unless care be observed water consumers on the West Side may be as seriously inconvenienced as people in the Town of Lake are now said to be.

By L. E. Cooley.

I do not quite like the way this thing has been going, so I will take up the North Shore and the West side, and see if I can not equalize things. We can look at the matter from four or five different standpoints. The first is the sewerage point, which Mr. Johnston referred to; the question of transit in the city, is a question of importance; the question of rail transit is important; the question of the crowded South side, and what we are going to do with this city in the future, and whether we want to congest the South side any more; the question of putting the site in order,—where the money is to come from—whether we want to spend two-thirds of our patrimony in getting ready to hold the Fair is another question. Another important question is what you are going to have left, after the Fair is over.

Now the sanitary question perhaps I give undue weight to. I un-

derstand a commission has been appointed to consider the sanitary aspect of the various sites, and these sites have been reduced to one site in each division. Now as to the Lake Front. We are urged to contemplate in this World's Fair question, what is equivalent I think to a population of 100,000 people, concentrated, say on perhaps one-half or two-thirds of a square mile. I understand that the specification which has been sent out to this Committee in regard to the sanitary question, is that they are to consider what would be the equivalent of a standing city of 100,000, located on 200 acres of ground. It becomes a serious sanitary question as to what is going to be the health of these people. This question of soil pollution is a very important one. If I were to select a site for the World's Fair, I should hunt clay, and keep off the spongy porous site,—keep off the sand,—keep off the mud. I think the vital statistics of this city will show that these porous sites become in time unhealthy, and I think that we can almost say that in the City of Chicago, the most healthy parts of it are those parts that are on the clay, and will continue to be more and more so in the future. No filth can get down into the ground water, and send gases up into the houses from beneath. In the last cholera epidemic which we had, people died on the sand hills, and not on the clay—they died over the porous soil. Now the holding a stock show for six months, concentrated upon a porous site, will give grave complications, unless great care is taken in the matter of providing for sewage and thorough drainage. It is a matter of important consideration. The question of water supply and pollution Mr. Johnston has discussed very fully. People get the idea that the pollution of the lake is not serious. I believe if as many people were killed in this city by railway accidents as are killed by polluted water, we would have every railroad president indited and in Joliet for fifteen years.

Let us examine these several sites in regard to this question. Jackson Park has from six to fourteen feet of sand on top of the clay, and is entirely unsuitable for a World's Fair site. The North side site lies from ten to twenty-five feet above the lake. In this respect it is far preferable to the other site. It would be an easy matter to drain the entire North side site over to the North branch. It has to be done some time, and it might as well be done now. In that respect, the North side has very marked advantages. As to the availability of the Lake Front, the question was raised the other day,—the Secretary of State Board of Health of Illinois raised it,—that he apprehended great danger from filling in so much ground here with fresh earth. This matter has been given a great deal of attention in Boston. The statistics in regard to the Back Bay, show that the filling has given origin to a great deal of typhoid. Sand might do away with that objection, to a certain extent. In regard to the North side site, it is practically the only one on the lake shore in which we could do away with the danger of sewage. The North side has a new tunnel, two miles long which provides an ample water supply. It is better provided than any other in this respect. Thus two points are satisfied. When you get over on the West side however, you have clay, with not very much soil on it, and it lies from twenty to twenty-five feet high.

It can be easily drained. It can be put in shape quicker and cheaper and better than any other site in this city.

Another point is in regard to the question of transit, reaching the World's Fair site. If we were to have visitors, 100,000 to 200,000 a day to the World's Fair, we would be in this position: People generally go to such a place 9 to 11 o'clock in the morning. The great majority of them leave 4 to 5 in the evening. Unless it is absolutely impossible to do otherwise, two-thirds of these people will probably use the street vehicles, which are restricted to three streets, Wabash, Indiana and State street for the South Side. The great bulk of the population of this city lies on the West Side.—nearly equal to the North and South Sides combined. There is no means of access to a South Side site South of 39th street except through the heart of this densely moving city, where we find difficulty in getting around to-day. We are shut off by railroad yards, lumber yards and stock yards from getting across anywhere, so the difficulty and the time required to reach the site Southward are very great, and I say, the movement is all constricted to three streets. The North Side site is far better. You can get a half dozen streets direct to the site. It will be a couple of miles closer than Jackson Park, you can reach it from the West Side with facility. The site on the West Side will be nearer to the centre of population than even the Lake Front. It will pretty nearly divide the city North and South, with nearly equal facilities to everybody, and be as near as possible to the centre of population, which is slightly West of Halsted streetand slightly South of Madison street. Another advantage which seems to me very important with regard to the West Side site, you are two miles closer to the heart of this city than any other site. It seems to me the people are not all going to live in hotels. They are not all going to stop at the Auditorium, they will distribute themselves on the West Side and at other places. People do not care to stop in the bustle of down town movement. If a man goes sight seeing all day, he wants to get some place where he can rest. There are a dozen streets running straight across this city,—a whole battery of them,—all of them susceptible to improvement. The movement can be largely by vehicles, and closer to where people want to go than any other site, the Lake Front not excepted. Now, that covers that point.

The third is the question of railway transit. Suppose you put the site next to the Belt line on the West Side. You have a belt line running from South Chicago to Evanston. It is close to every suburb, every train, —the whole North-West. Every railroad can run special trains to the World's Fair without going to the heart of the city at all,—without blocking our traffic. The railroads are placed on a par in regard to it, and that is an important thing. I think it important that the railroads that are coming into Chicago, and are bringing the people to Chicago, be placed on a par in this matter. They want to advertise the matter throughout the whole country. Put it on the West Side, and every railroad is like situated in regard to it, and people can get to the suburbs and live there, and run special trains from the suburbs without coming to the heart of the city. There is no other point that possesses equal advantages to the

West Side in this respect. There is not a depot in this city but what you can run trains from to the West Side. Every depot in this city can send trains to it.

As to the question of crowding up the South Side, I have already spoken of that. I believe in 30 years we will tear down Madison street from one end to the other, and widen it. They are doing it to the Strand in London. If we do not do that, the streets will not hold the people. We are building great tunnels of our streets here, saturated with moisture, —keeping out sunlight,—we are building high buildings,—why, if one of those high buildings were suddenly emptied, if every body were precipitated into the street to-day from them and anything happened to excite them, they would crush themselves to death. The street would not hold them. You have too much here on the South Side already. You don't want anything more. You want to begin to spread. It is not political economy, civic economy or any other economy, except to a lot of shopkeepers who want to concentrate things around this Lake Front.

Now, the question is, what are you going to have left after you get through. I wish it could be that there would be a square mile or 1,000 acres, near to the belt line road, upon which trees would not be planted —nothing but grass grow,—which would be left as a play ground for the people,—permanently reserved. We have no such place in this city,—and that is the place for it, because in 30 years, it will be the centre of population. That centre is moving Westward. It cannot move into Lake Michigan very far without getting drowned; it has to go West and any point to-day that is within half a mile from the belt line road will be the center of this city in 30 years. We need to have reserved there just as much ground as we can get. I wish we had 2,000 acres, that would be a permanent reservation for all sorts of of civic displays. Such a thing would be a fitting legacy from this World's Fair. If you have any buildings to leave on it, leave them. That is all I have to say.

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PROCEEDINGS.

MONTANA SOCIETY OF CIVIL ENGINEERS.

June 21, 1890. The regular monthly meeting of the Society was held at 8:30 p. m. at the office of Mr. Beckler. Second Vice-President John Herron occupied the chair. There were present Messrs. Sizer, Pearis, Danse, Whitcomb and Keerl.

Minutes of adjourned meeting of May 31, read and approved.

The application of Mr. W. L. Loveland for membership was read and ordered filed, and the Secretary directed to issue the usual letter ballots.

Mr. Danse presented and read the following committee report:

HELENA, Montana, June 3, 1890.

To the Montana Society of Civil Engineers:

GENTLEMEN—Your Committee appointed May 31st, to select a candidate for Secretary of the Society, in place of Mr. Charles G. Griffith, resigned, report that they find that the duties of the Secretary entail a large amount of correspondence with the other Societies, with the Board of Managers of the Associated Societies, with the members of this Society, as well as a good deal of writing to keep the minutes of meetings and the general business of the Society in good shape; that all this takes time, which an Engineer in active practice cannot well spare, and that therefore the Secretary has to employ assistance to enable him to do the work in a creditable manner. Your Committee therefore recommend that the sum of one hundred and twenty-five dollars ($125) be appropriated annually, and paid to the Secretary, out of which sum he may employ clerical assistance. We recommend that the due proportion of this amount be rated and appropriated at once for the services of the Secretary from June 1, 1890, to the end of the fiscal year of the Society.

We recommend that Mr. James S. Keerl be elected Secretary for the remainder of the current year, beginning June 1, 1890.

Respectfully submitted.

W. A. HAVEN,
ALBERT S. HOVEY, } Committee.
L. C. DANSE,

The report was received and ordered filed.

In speaking upon a motion made by Mr. Sizer to adopt the report, Mr. Keerl stated that he regretted the Committee had not named another than himself as the candidate for Secretary and Librarian, for should he accept the position his limited time would only permit his attention to its duties in a directory sense. He felt assured there were others in the Society who would be enabled to give the duties more personal attention, and possibly at a less cost to the Society. He called attention to the qualifications of Mr. C. F. Pearis for the position, and offered as an amendment to the existing motion that Mr. Pearis' name be substituted in the Committee's report in lieu of his own. Mr. Pearis stated that while he appreciated the honor conferred upon him by the mention of his name in this connection, he must decline, as he considered the knowledge of the position possessed by the gentleman named by the Committee as of value to the Society, and that while he would gladly tender any assistance that he could in accomplishing the duties of the office, he hoped the gentleman as now named in the report would see his way clear to accept the nomination.

Mr. Keerl stated that if the Society insisted upon his acceptance of the position

he felt as if his interest in its cause would hardly warrant a refusal to serve, but that he would not desire to accept the office under a salary. As far as his own services were concerned he would gladly donate them, but he would expect the Society to meet the necessary expenses for clerical services.

The original motion being withdrawn, the following was made and carried:

That the Committee's report be adopted, excepting that portion recommending a salary be paid to the Secretary, and that in lieu thereof the following be substituted: That whatever clerical assistance the Secretary may find necessary in the proper discharge of his duties shall be paid for by the Society.

The Secretary was instructed to issue letter ballots upon the nomination of J. S. Keerl for Secretary and Librarian, in accordance with Section 1, Article V. of the Constitutton.

The Secretary was instructed to report the proceedings of this meeting to all members.

A letter was read from Mr. E. P. H. Harrison, stating that for the present he expected to remain in the East an desired temporarily to withdraw from active membership. Request granted, and his name ordered on the list of Associate Members.

The Secretary was authorized to purchase a desk for his office not to exceed in cost $50.

The Secretary was authorized to charge the two members now retiring one-half the annual dues for 1890.

Adjourned. J. S. KEERL, Acting Secretary.

July 19, 1890. The regular monthly meeting was held at the office of Mr. E. H. Beckler, Chief Engineer Montana Central Railway. Mr. John Herron, 2d Vice-President, in the chair. There were present Messrs. McHenry, Danse, Wheeler and Sizer.

Mr. H. L. Sizer was elected Secretary pro tem.

The letter ballots were submitted upon the name of W. L. Loveland for membership and he was declared elected a member of the Society.

The letter ballots upon the election ot a Secretary and Librarian were presented and Mr. J S. Keerl was declared elected to fill said offices until the next annual meeting.

A number of communications were presented, three of which were laid over until the next regular meeting, as unfinished business.

Adjourned. F. L. SIZER, Secretary pro tem

ASSOCIATION OF ENGINEERING SOCIETIES.

ORGANIZED 1881.

Vol. IX. October, 1890. No. 10

This Association, as a body, is not responsible for the subject matter of any Society or for statements or opinions of any of its members.

RIVER POLLUTION IN THE UNITED STATES.

BY CHARLES C. BROWN, MEMBER ENGINEERS' CLUB OF ST. LOUIS.

[Read June 18th, 1890.]

This paper is presented to the Club as a resume, as complete as may be, of the work that has been done in this country in determining and showing to what pollution our streams are subject, to call attention to the importance of the subject, and if possible, to excite discussion.

I have been engaged more or less of the time for two years in determining the amount and sources of pollution of various streams in the State of New York, and have seen clearly the great and growing importance of a thorough awakening of the people upon the subject and the desirability of discussion as to the best methods of preventing the increase of pollution and in many cases of reducing the amount of polluting matter now entering certain streams. I am quite selfish in the matter, as well as solicitous for the improvement of the streams, as I am at present engaged upon the investigation of the water-shed of one of our great rivers, and want all the light I can get before beginning the final discussion of results.

The streams have divided themselves in my mind into three classes: 1. Those that are used as sources of water-supply, and are evidently to be used for this purpose alone. These can readily be disposed of, and are in the State of New York, by the methods used for the Croton River and described in my paper before the Club last year. 2. The streams which can not be used for water-supply, and can, in many cases, be used as drainage channels. The principal question with this class of streams is as to the amount of polluting materials which can be allowed to enter them without producing nuisance or interfering with life or property in them. There has been some discussion of this portion of the subject, and maximum limits of pollution have been assumed by some authorities upon the basis of obtainable information as to the effect of given amounts of polluting matter (estimated with greater or less accuracy)

upon a stream of a given flow. 3. The streams which are in use as sources of water supply for domestic purposes and are at the same time used as drainage channels into which all sorts of filth are discharged. The greater number of our larger rivers and many of the smaller ones belong to this class. While theoretical considerations demand the rigid exclusion of most kinds of artificial pollution from streams used for potable water supply, it is practically true that these considerations are lost sight of in very many cases and in a large proportion of these cases with little or no apparent evil effect, though the evil effects are quite noticeable in some cases. Aside from the statement of and argument for the theoretical considerations referred to, the discussion of this branch of the subject is very limited. It is, practical y, the most important, because the largest branch of the subject, and a practical discussion with as many data as can possibly be obtained is very much needed.

I will confine this paper as closely as possible to this third division, and, as the title of the paper indicates, to work done in this country.

Some work has been done in several States. Of these, I have some knowledge of that done in Maine, Massachusetts, Connecticut, New Jersey, Pennsylvania, New York and Illinois. It is probable that some work has been done in other States, and, if so, I shall be very glad to add the results to the data I have on hand, and shall feel much indebted to any one who can supply them.

The work done in Maine, as given in the Reports of the State Board of Health, is entirely chemical in its nature, and consists of analyses of samples of the waters supplied to villages and cities by the various water companies and corporations in the State. All the water supplies in the State are represented, but two, by several samples taken at various times of the year. Those of interest to us in the present discussion are those from rivers. But few corporations in Maine take their supplies from rivers; more take them from lakes and ponds which are usually with small water-sheds and with little population to produce dangerous pollution. The average results of the examinations of supplies from rivers are here given.

All results of chemical analysis in this paper are reduced to parts per 100,000.

Cities.	Augusta.	Bangor.	Biddeford and Saco.	Brunswick.	Calais.	Lewiston.	Waterville.
No. of Samples..	5	3	6	3	6	5	4
Total Solids.....	3.7	4.4	2.8	3.8	3.6	3.8	3.3
Loss on Ignition.	2.1	2.7	1.5	2.0	2.5	2.4	2.1
Hardness........	1.99	1.86	1.08	2.03	1.59	1.65	1.75
Chlorine...... .	0.2	0.16	0.26	0.4	0.27	0.2	0.26
Free Ammonia..	0 0012	0.0003	0.0001	0.008	0.0005	0.0005	0.0007
Organic "	0 0152	0.0183	0.0128	0.0153	0.0208	0.0158	0.0155

In none of the samples is there more than a trace of nitrites or nitrates. None of the water-sheds are densely populated and all seem, from the standpoint of the analyses and from a consideration of the amount of population to be quite free from danger. The same can be said of the systems drawing their supplies from brooks and lakes. The following were taken on June 7th and 8th, 1888, as a beginning of a series to show the fluctuations of pollution in the river waters, but the series was interrupted and the few here given are all that have yet been published. They are too few in number to be of much value. No. 130 is from Carrabassett River at the village of No. Anson. No. 131 is from Kennebec River. No. 132 ditto below the city sewers. No. 133 is from Moosehead Lake. No. 134 is from Kennebec River and No. 135 from Dead River just above the Forks. "No deductions can be made from the results of the analyses, particularly from the two samples collected from the Forks, for the water was very high at the time and the streams were crowded with logs."

No.	Total Solids.	Loss on Ignition.	Hardness.	Chlorine.	Free Ammonia.	Organic Ammonia.	Nitrites.	Nitrates.
130	2.8	1.8	1.27	0.2	0.000	0.012	None.	Slight Trace.
131	3.4	2.4	1.56	0.3	0.000	0.013	"	"
132	3.4	2.4	1.69	0.3	0.000	0.014	"	"
133	3.0	2.4	1.56	0.2	0.000	0.013	"	"
134	3.8	2.6	1.27	0.4	0.000	0.017	"	"
135	4.2	2.0	1.43	0.3	0.003	0.022	Slight Trace.	"

Nearly or quite all of the waters here examined belong to the first class of waters, those that can be used without question for water supply if ordinary precautions are followed, as the population on the water-sheds is comparatively sparse and is not subject to great concentration in large cities. The results are of interest for purposes of comparison.

The State of Massachusetts has done more work on the investigation of the pollution of rivers than any other State. The work in this state has proceeded at a greater or less rate since the year 1873, and quite a mass of data has been obtained which is being added to each year. I have time to make only a very condensed statement of the results of these investigations as they have been published. I will try to make this statement as clear as possible in so far as the work done has a bearing on the principal subject of this paper. I would refer to the reports of the State Board of Health of Massachusetts for the detailed results, especially those of 1874, 1876, 1886, 1887, and 1888 supplement, and the reports of the Massachusetts Drainage Commission.

The principal rivers examined are the Merrimack, Blackstone, Chicopee, Taunton, Charles, Sudbury and Concord, Neponset, and other sources of supply for the Boston Water Works. The Merrimack is used for sewerage and mill drainage as well as for water supply, the Blackstone

is not used to any considerable extent for water supply, but is small enough to become somewhat of a nuisance from sewage and mill drainage. The others are small and portions of them come under both the above classes.

The examinations were made by chemical analysis and by actual count of the principal sources of pollution, such as sewerage systems of villages and cities, and refuse solids and liquids from mills.

The following table gives the results of examinations of the Merrimack at different points. It is taken from W. R. Nichols' report of 1874, and shows the variation in the relative amount of pollution at different points. The table is followed by an abstract of Mr. Nichols' interpretation of the results.

	Mean of 11 Examinations above Lowell.	Mean of 12 Examinations above Lawrence.	Mean of 11 Examinations below Lawrence.
Ammonia	0.0047	0.0044	0.0031
Albuminoid Ammonia	0.0114	0.0110	0.0127
Inorganic	2.37	2.41	2.64
Organic and Volatile	1.73	1.69	1.79
Total Solid Matter	4.10	4.10	4.43
Chlorine	0.14	0.20	0.18

The first column gives results above the great sources of pollution, the second below one, and the third below two. The question arises as to what becomes of the vast amount of polluting matter which is known to enter the river.

1. Oxidation is shown by the individual results to be an agency of almost no effect in disposing of the polluting matter. The effect is too small to be measured.

2. Deposition doubtless removes a very large proportion of the matter from the water. This deposition is of the insoluble matter which may be so at time of entrance, or be made so by chemical action, especially in the case of discharges from mills. These deposited materials, in the case of the streams of the class of the Merrimack, are taken up by floods and swept on down the stream, or are covered by other sediment in the form of earth or similar matter and are thus purified or removed as a source of danger.

3. Dilution is a great reducer of the proportional amount of pollution. It was estimated in 1873 that, at the minimum stage of the river it would be necessary to discharge 100 tons of dry soluble matter into the river per day to increase the amount of solid matter in solution by one grain per gallon, and that the amount of chlorine discharged into the river was 400 tons per annum, or but little more than one ton per day. It will be observed that the amount of water entering the river from less polluted sources, between the points of observation above and below Lawrence is sufficient to reduce the proportional amount of Chlorine in the water. This effect must

be laid to dilution as the compounds of Chlorine to be found under these circumstances are almost or quite all soluble.

Other examinations of the river were made in 1879 and 1886. The caution is given that the results are not sufficiently numerous to insure that the average condition of the water each year of examination is obtained, and that if this average condition has not been obtained, the results are not strictly comparable. The following table gives the averages of the results for the three years and is of interest as showing the increase in the relative amount of pollution with the increase in population and in number of mills. This table is taken from the report of Mr. F. P. Stearns in the State Board Report for 1887.

Place.	No. Exams.	Date.	Ammonia.	Albuminoid Ammonia.	Chlorine.	Residue. Fixed.	Residue. Volatile.	Residue. Total.	Hardness.
Above Lowell	11	1873	0.0047	0.0114	0.14	2.37	1.73	4.10	
" "	7	1879	0.0047	0.0131	0.40	2.00	2.50	4.50	
" "	2	1886	0.0031	0.0155	0.35	1.95	2.15	4.10	1.00
Below "	2	1873	0.0038	0.0198	0.20	2.64	2.39	5.03	
" "	4	1886	0.0034	0.0176	0.39	2.55	2.07	4.62	1⅙
Above Lawrence	17	1873	0.0044	0.0110	0.20	2.41	1.69	4.10	
" "	6	1879	0.0018	0.0131	0.44	4.62	2.94	7.56	
" "	4	1886	0.0066	0.0173	0.41	2.78	2.20	4.98	1½
Below "	9	1873	0.0030	0.0130	0.18	2.61	1.73	4.34	
" "	9	1886	0.0138	0.0244	0.46	3.22	2.15	5.37	1½
Above Haverhill	6	1873	0.0033	0.0114	0.18	2.78	2.04	4.82	
" "	2	1886	0.0058	0.0207	0.44	3.26	2.39	5.65	1½

As an aid to the understanding of these results the following facts are stated.

" The distance between points above and below Lowell where samples were taken in 1886 is about 3½ miles. Within this distance the river receives the refuse from the mills, the sewage of the city of Lowell (population in 1873, 46,000; in 1879, 58,000; in 1886, 65,000), and the flow from the Concord River and Beaver Brook, which combined have a drainage area about ⅛ as large as the Merrimack River at Lowell. In the latter part of the distance the water flows over some rapids known as Hunt's Falls, falling about 11 feet. From the sampling place below Lowell to above Lawrence the river flows without noticeable fall, and receives very little addition to its volume. From above to below Lawrence the distance is 2.2 miles. In this distance the water falls about 30 feet, is increased in volume from one to two per cent. by the addition of the Spicket River and receives the drainage from the mills and from the city of Lawrence. The population of Lawrence in 1873 was 33,000; in 1879, 38,000: in 1886, 39,000. From the place of sampling below Lawrence to the one above Haverhill is 6¾ miles. In this distance the Shawshine River adds one or two per cent. to the volume of the larger river and the water falls a few feet in rapids."

Judging by the results for Albuminoid Ammonia and Chlorine there is a marked increase in the amount of pollution with the time. The indication of this is sufficiently strong to admit of no question. The indication of an increase in pollution down stream is equally decisive. There is evidently a decrease in pollution during the time that the water is flowing from one city to the other, during which time it receives no additional pollution, but there is enough remaining to make with the increase by the drainage of the lower city a larger quantity than before. In other words, the purifying action during the flow of the river between the two cities is not sufficient to remove a very appreciable amount of the pollution. Below Lawrence where the river receives some additions as well as flowing a greater distance the purifying and diluting effect is no more strongly marked.

These results bear out the statements of the Rivers Pollution Commissioners of England, and show as clearly as such rather meagre results can that the pollution of our rivers that run through populous districts, especially manufacturing districts, is cumulative, and that unless there are appreciable accessions of water from unpolluted sources, the river will purify itself but slightly.

Results for 1887, published in the report for 1888, show about the same amount of total solids, but differently distributed, the amount of Volatile matter being less than in 1886. The amount of Chlorine is also less by 30 to 50 per cent. but the results show the same tendency to an increase of pollution as we go down stream.

The Blackstone River is of a different nature. It is a small river and receives a large amount of pollution early in its course from the sewage of the city of Worcester and the refuse liquors from wire works and similar establishments. The amount of pollution it receives below this point is relatively small, while the amount of water it receives from unpolluted sources is comparatively large. We should therefore expect a reduction in the relative amount of pollution in the river and the expectation is realized.

Results of chemical examinations are given in the reports for 1874 and 1876 and a statement of the observed sources of pollution of particular importance is given in that for 1876. The following table is abstracted from the table of results in the report for 1888 and gives the means of the results there given. All results show the same thing and these are taken because they are in the most convenient form. The mean is of six or seven results in each case. The location of the examinations is as follows:

1. Leicester Storage Reservoir, above the city.

2. Worcester, one mile below outlet of Worcester sewer; about 75 square miles of watershed.

3. Uxbridge, after dilution of Lake Quinsigamond and other tributaries, total watershed above this point about 150 square miles.

4. Millville, near the Rhode Island boundary, total water shed above this point about 276 square miles.

The second result shows the very great pollution with which the river leaves Worcester. The amount of this pollution is said in the reports to

be sufficient to give the water a dark, turbid appearance, which would lead one to expect a greater amount of impurity than the chemical analyses show. There is apparently an increase in the amount of impurity in

No.	Free Ammonia.	Albuminoid Ammonia.	Nitrogen as Nitrates.	Total Solids.	Loss on Ignition.	Fixed Solids.	Chlorine
1	0.0057	0.0194	0.004	3.15	0.95	2.21	0.15
2	0.2471	0.1578	0.018	24.93	6.59	18.34	1.39
3	0.1148	0.0430	0.034	7.36	1.43	5.92	0.79
4	0.0492	0.0233	0.021	5.31	1.28	4.03	0.51

the river at each of the points 3 and 4 above of about 50 per cent. from 1873 to 1888. It is evident that there is a considerable reduction in the proportional amount of pollution as the river flows. The great source of pollution is Worcester. A much smaller amount reaches the river below, almost altogether from factories. There is a considerable dilution of the water from comparatively unpolluted sources, the amount of which can be estimated from the extent of the water shed above each point at which samples were taken, as stated above.

Of other rivers in the State we have some results for a year or two each in the cases of the Chicopee and Taunton, and others at frequent intervals from several smaller rivers and lakes which are used as sources of water supply and are therefore kept as clean as possible, and do not really belong to the class of streams we are considering. The results for the two rivers just previously mentioned are not numerous enough to make it worth while to reproduce them here. The State and the cities and villages interested are just entering upon the construction of a great system of sewers for the removal of sewage from the watersheds of the water supplies of the Metropolitan District which will thus render them quite free from pollution.

Many new results are promised in a supplement to the last report (1888) which has not yet appeared. Biological analyses are also in progress but the results are not yet available.

The State Board of Health of Connecticut presents in its report for 1888 some general statements of the flow of certain rivers and of the amount of pollution they receive. There are a few results of chemical and bacteriological examinations, but they are too few in number to be of much value for purposes of comparison and need not be reproduced here.

In New Jersey the Passaic river has been used for many years as the source of water supply for Jersey City, Newark, and for portions of the time for other cities and villages. It also receives the sewage from several places and is somewhat polluted at the intakes by sea water. Chemical examinations of the water at various places have been made at frequent intervals and the increase of pollution in the course of the river and with time has been approximately determined. Some of these exam-

inations have been made for the Aqueduct Boards of the cities, some for the Joint Board of Newark and Jersey City on the Pollution of the Passaic, and some for the city of Newark in a suit for an injunction on the city of Passaic to prevent the discharge of sewage into the stream from the new sewer system in that city. But few of these results are as yet attainable. I think that but few of them have been published. I extract a few characteristic groups from some that have been published, for which I am indebted to Professor A. R. Leeds, who made many of the examinations. Considerable work has been done by the "Joint Board" in reducing the amount of pollution from manufactories and it is hoped that the final decision of the injunction suit will be favorable to the purity of the river, though the decision of the lower court is against the city of Newark. Some biological analyses have been made, but no organized investigation on this line has been entered into.

The following averages are taken from the report of Professor Leeds for 1883. The results of these averages are scattered through the year except in the case of the last two stations where the samples were taken in the spring months.

Station.	1	2	3	4	5	6
No. Results.	11	11	1	9	4	4
Free Amm......	0.0122	0.0067	0.007	0.0115	0.0313	0.0048
Alb. Amm......	0.0240	0.0207	0.023	0.019	0.054	0.017
Nitrites.........	0.0007	0.0007	None	0.00005	0.0006	——
Nitrates........	0.365	0.325	None	0.00003	0.00034	——
Oxygen req'd...	0.46	0.40	0.39	0.43	1.17	0.40
Chlorine........	1.54	0.69	0.55	0.55	1.02	0.35
Hardness........	4.6	4.6	3.3	4.35	——	——
Total Solids....	20.2	8.86	10.0	9.07	9.5	6.25

Station 1 is at the Jersey City intake, which is above the city of Newark and is subject to some pollution from the sewage of that city brought up by the action of the tides.

Station 2 is at the Newark intake, which is farther up the river but is still within the influence of the tides and the sewage of the city of Newark. Both are below the cities of Paterson and Passaic and receive pollution from both sources though that from Passaic has been small in the past as it is but just constructing a sewer system.

Station 3 is 2000 feet above the Newark intake and about at the upper limit of pollution from down stream sources.

Station 4 is at the Avondale Bridge and is practically out of reach of pollution from below except under unusual circumstances.

Station 5 is at the city of Paterson and the results here represent the effect of the sewage of Paterson.

Section 6 is above Beatty's Dam, above Paterson and represents the stream in what may be called its original condition, as there are no sources of concentrated pollution above this point.

The work in the state of Pennsylvania has been principally in the line of investigation of the present and proposed water supplies for the city of

Philadelphia. Detailed inspection of the water sheds of the Schuylkill, the Delaware and some of its tributaries have been made and statements made of the sources of pollution from sewage and from manufacturing refuse. These reports are printed in the reports of the Water Department of the city of Philadelphia. Chemical examinations of the water from the various streams have been made at frequent intervals and the results published as above. I am indebted to Professor Leeds for the tables from which I abstract the following.

The first table gives the results of a series of samples, all taken on the same day at different points on the Schuylkill river, intended to show the increase in pollution in the course of the river. The first station is at Kissinger's Bridge, above Reading, and all the larger sources of pollution, and all sources except mines and mining towns. The second is at Pottstown above Manatawny creek, the third above Phoenixville pumping station, the fourth at the intake of the Norristown waterworks, the fifth at the intake of the Conshohocken waterworks, and the sixth at the Roxborough pumping station of the Philadelphia waterworks. Each station is farther down stream than the one before and the river has received the additional pollution of the city above and other population, but has had some opportunity to purify itself in its flow to the point at which the sample was taken. The increase in pollution is evident on an inspection of the results. The exact nature of the polluting matters is given by the sanitary survey of Mr. D. C. Barber which gives the amount of population contributing to the pollution in each district and the method of drainage, and also the character of the polluting matter from manufactories and mines.

STATION	1	2	3	4	5	6
Free Amm.	0.0035	0.0040	0.0025	0.0036	0.0010	0.0015
Alb. Amm.	0.0140	0.0085	0.0100	0.0075	0.0140	0.0100
Oxygen req'd.	0.058	0.14	0.19	0.13	0.23	0.15
Nitrites,	——	0.00005	0.00005	0.00008	0.0005	——
Nitrates	0.96	0.92	0.92	0.86	0.86	0.80
Chlorine	0.20	0.25	0.25	0.25	0.06	0.20
Hardness	2.5	3.5	3.70	——	——	3.0
Total Solids	9.0	11.5	10.5	10.5	10.0	11.5

The following table shows the increase in pollution in the Delaware river with the increase in populated area draining into it.

LOCALITY.	WATER GAP.	BYRAM.	FRANKFORD.
NO. SAMPLES.	13	44	17
Free Amm.	0.00249	0.0028	0.00385
Alb. Amm.	0.0105	0.00988	0.0149
Nitrous Acid.	0.000005	0.000022	0.00004
Nitric Acid.	0.2393	0.2543	0.328
Oxygen req'd.	0.29	0.315	0.308
Chlorine.	0.227	0.266	0.329
Total Solids.	4.91	6.88	8.300

The amount of pollution above the Water Gap is very small, being from small villages, almost none of them having systems of sewerage. Byram is below the entrance of the Lehigh river and the amount of pollution is considerably increased. Frankford is close to the city and has the maximum of pollution.

In these reports are numerous sets of results to show the effect of the season of the year, the amount of water flowing, the covering of the surface with ice, the intermixture of tributaries, the addition of specific manufacturing refuse, and so on, which are very interesting and valuable, but we have no room for them here. I would refer anyone wishing to examine the subject more carefully to the reports of the Philadelphia Water Department.

In the State of Illinois a very elaborate investigation of the Illinois river has been begun in connection with the discussion of the proposed discharge of Chicago sewage with a diluting volume of lake water into the Illinois River through the Desplaines. This investigation includes an examination of the water chemically, to determine the present amount of pollution at different points, and the ability of the river to purify itself, by aeration, oxidation or dilution. Bacteriological analyses are also in progress; and hydrographical surveys are also in progress. A preliminary report on the investigation is now in print and I draw some of the results therefrom. The final discussion and conclusions must be left until the work is finished and the results digested.

The report on the hydrographical survey is very complete on the portion of the work already done, and covers a statement of the geological characteristics of the portion of the district examined; a discussion of the effects of inhabitation upon the high and low water levels; the population distribution, present and prospective; the extent of the basins tributary to the river; and detailed descriptions of the flow of water, levels and peculiarities of the Desplaines and Kankakee watersheds, which two streams unite to form the Illinois river. The results of this investigation are of the utmost importance in the discussion of the particular case, and the method used can probably be advantageously employed in many similar investigations, but they are in such shape, of necessity, that it is very difficult to do them justice in an abstract, and in this place under my present limitations as to time and space, I will not attempt it.

Some chemical examinations of the water of the river at different points were made in 1886, many more were made in 1888 and 1889. I have combined the averages of these results in the following table for ease of comparison. The results for 1886 and 1888 are for samples collected in the summer months; those for 1889, in the winter months. This should be remembered as the rate of purification may be expected to be less in winter than in summer, though the actual pollution may at times be less in winter owing to the greater dilution. Some results for water flowing in the channel under ice are given in the report to show that the ice has a very marked effect in retarding the rate of purification of the water. An explanation of the peculiarities of each item so far as needed for our present purpose follows the table.

No.	Date.	Total Solids.	Suspended Matter.	Chlorine.	Free Ammonia.	Albuminoid Ammonia.	Oxygen Consumed.	Nitrogen in Nitrates.
1	'86 '88 '89	 47.12 37.66	 12.92 2.72	 4.68° 6.29—	2.656 1.225 0.892	0.163+ 0.256° 0.281—	2.62 2.31 2.65	 0 0
2	'86 '88 '89	 43.12 40.86	 6.98 2.46	 4.61° 5.61—	1.273 1.088 0.815	0.075+ 0.199° 0.168—	1.10 1.62 2.28	 0 0
3	'88	44.17	9.40	3.91°	0.745	0.167°	1.57	0
3A	'86 '88 '89	 44.27 43.28	 10.79 5.55	 4.37° 5.77—	0.943 0.893 0.849	0.043+ 0.168° 0.267—	0.93 1.43 2.17	 0 0
(4)	'88	29.47	1.41	0.58	0.042	0.035	0.47	0.031
(5)	'88	25.14	3.56	0.14	0.008	0.059	1.44	0.009
6	'88 '89	35.59 32.28	3.08 2.91	3.21° 2.87—	0.411 0.472	0.071° 0.159—	1.09 1.07	0.038 0
(7)	'88	33.03	4.63	0.42	0.012	0.047	0.68	0.003
8	'86				0.041	0.024+	0.53	
(9)	'88	45.06	8.78	0.55	0.013	0.034	0.69	0.036
(10)	'88	37.51	3.08	0.57	0.018	0.041	0.72	0.036
11	'88 '89	34.57 41.76	5.03 9.38	1.97° 1.31—	0.064 0.146	0.053° 0.064—	0.86 0.86	0.104 0.094
12	'88 '89	30.60 31.60	2.75 3.09	1.77° 1.17—	0.047 0.106	0.048° 0.040—	0.87 0.86	0.068 0.096
13	'86 '88	 32.98	 5.43	 1.24°	0.003 0.021	0.019+ 0.052°	0.48 0.98	 0.089
13A	'89	33.10	2.69	1.29—	0.164	0.055—	0.96	0.051
14	'88 '89	35.30 35.20	8.43 4.35	1.62° 1.18—	0.064 0.159	0.065° 0.102—	0.94 1.34	0.080 0.126
15	'88 '89	30.18 35.44	4.54 8.08	1.16° 0.93—	0.034 0.108	0.043° 0.055—	0.81 0.92	0.073 0.041
(16)	'88	31.78	7.07	0.36	0.005	0.028	0.55	0.075
17	'88 '89	39.00 31.78	8.47 5.63	0.75° 0.69—	0.020 0.076	0.038° 0.036—	0.74 0.55	0.062 0.097
18	'88 '89	30.16 41.08	5.03 4.46	0.92° 0.75—	0.009 0.087	0.048° 0.072—	0.73 0.98	0.058 0.009
(19)	'88 '89	27.86 30.99	7.52 6.13	0.41° 0.58—	0.017 0.042	0.036° 0.040—	0.74 0.76	 0.032

Results in ( ) are from tributaries of the Illinois.

No. 1 is at Bridgeport on the Illinois and Michigan canal, where 50,000 cubic feet a minute of water are pumped from the South Branch of the Chicago River into the canal. The water thus pumped is very greatly polluted by the sewage of a half million or more of people in Chicago, as is shown by the analyses. This sewage is not fresh, but has had some opportunity to decompose in the river before reaching the pumping station. The relative amount of pollution varies somewhat from time to time as winds and currents vary the amount of water which is carried into the river from the lake. The method of taking the averages is said to eliminate to some extent, the effect of this variation upon the results, in their relations to each other. It is evident that there is here no opportunity to study the question of increase in pollution with the time.

No. 2 is at Lockport, 29 miles down the canal from Bridgeport, with no dilution except from rain, and no sedimentation of the suspended matter because of the rapidity of the current and the action of passing boats. The purification depends then almost entirely upon chemical and organic action. That there is an appreciable amount of purification is evident from the table. The purification during the winter is less than during the summer, as shown by a comparison of the '88 summer results with the '89 winter results. These results give rather different conclusions from those in Massachusetts where the principal sources of purification are said to be dilution and sedimentation.

No 3 is at Lock 5 at Joliet. The Desplaines River and the canal unite at this point, but the flow of the river during the summer of 1888 was so small that its diluting effect may be neglected.

No. 3A is at dam 2 just below Joliet, 33 miles below Bridgeport. Between the two places at Joliet, the river receives the sewage of a part of Joliet and the State prison. The effect of this sewage is seen on comparing the two results for 1888, at No. 3 and No. 3A. The dilution by the Desplaines River in 1889 is probably considerably greater than in 1888 owing to an increase of flow in the winter. The effect of reduction in rate of purification owing to the cold is greater than the effect of dilution, as the table shows.

No. 4 is at Channahon on the DuPage River and shows the quality of one of the diluting streams. This stream is small and its diluting effect during the summer of 1888 can almost be neglected. The Desplaines River water shed, including the DuPage is 1,392 square miles.

No. 5 is at Wilmington on the Kankakee River and shows the character of an important source of dilution. The Kankakee water shed is 5,146 square miles.

No. 6 is at Morris below the entrance of the Kankakee. The total water shed above the point is 7,296 square miles. An additional purification is observed.

No. 7 is from the Fox River above Ottawa. Its water shed is 2,700 square miles.

No. 8 is at Ottawa in 1886 and is strictly comparable only with the results of that year.

No. 9 is from the Big Vermillion at LaSalle. Its water shed is 1,317 miles.

No. 10 is from the Little Vermillion at LaSalle. Its water-shed is 165 miles.

No. 11 is from the Illinois River at LaSalle. The total water shed to this point is 11,847 miles.

No. 12 is at Henry. The area of water shed above is 12,642 miles.

No. 13 is at Peoria, at the inlet to the water works. The total water-shed above is 13,479 miles. No. 13A is at the upper bridge.

No. 14 is at Pekin. The area of water shed is 13,831 miles.

No. 15 is at Havana. The area of water shed is 15,364 miles.

No. 16 is on the Sangamon River, whose water shed is 5,670 miles.

No. 17 is at Beardstown. Area of water shed, 23,444 miles.

No. 18 is at Grafton, near the mouth of the river, total water shed 27,-914 miles.

No. 19 is in the Mississippi River at Alton, below the mouth of the Illinois.

The statements of area of water-shed give an idea of the comparative amount of water flowing at the different points and also some idea of the population whose drainage enters the river directly or indirectly, if the metropolitan district is not considered. There are some data as to population in the report, but they are not in such shape as to be of use to us in this paper without more labor than I have time to put on it just now. The data as to direct pollution from cities and towns and from manufacturing establishments are not enough to give much idea of the amount of pollution entering the river from other sources than the canal. That there is an appreciable amount of this pollution is shown by the increase in the amounts as indicated in the chemical analyses at some points down the river far enough to be well out of the influence of the pollution with which the river starts. Doubtless additional information and discussion of this point will be given in the final report.

The original work in the State of New York has consisted principally of the investigation of the pollution of sources of potable water supply for various cities and villages of the state. By law, the State Board of Health is empowered to make rules for the sanitary protection of water-sheds of corporations in the state and it has been called upon by several cities and villages to make such rules. I would refer to my paper before the Club last year for a description of the method of investigation of New York City's supply. This was only a larger and therefore somewhat more fully treated example of the work done upon the various water-sheds.

Last year a law was passed that gave the State Board of Health certain powers over plans for sewerage and drainage of villages in the state taking advantage of the provisions of the act to construct sewers. One of the questions that arose very early in the discussion of such plans was as to the pollution of streams by the discharge from such sewers. In some cases the water is used below for village or city supplies and there is a possibility of detrimental action upon such water. This is of course the case with tributaries to the Hudson, which is used for water supply until salt water is reached, viz: to Poughkeepsie. The board has therefore

thought it best to institute an investigation of the question and an inspection of the Hudson has been begun. Some work was done last summer, but not enough results have been yet secured to warrant their publication, except as to a minor matter, not touched upon in this paper. In working out a plan for the investigation I have gathered the data of which I have tried to give you some idea above.

All the work on the subject that I have been able to get reports of has been touched upon above, except some investigations of small streams for water supply. I am very anxious to get hold of anything else that has been done, and that is one of the objects with which I have written the paper. It is very evident from the above statement that very little indeed has been done on the subject in this country, and it is also evident that all that has been done shows that the question is a very important one. The more thorough the work the more evidently is it shown that the continued use even of our largest rivers, as both sewers and sources or water supply can not be permitted. The larger the river and the more favorable the conditions of purification the longer this double use can be continued, but in the more thickly populated portions of our country the use of even the largest rivers is becoming questionable.

I would be glad to have an expression of opinion from members of the Club upon the following statement, to which my present knowledge of the subject leads me. Granted the importance of the investigation and the necessity of some action in the matter, the most practical course of procedure is to make a detailed inspection of the watershed of the stream in question to determine the actual sources of pollution and the amounts thereof, and the nature of the effect upon the water. Data as to the amount of the minimum flow of water, which occurs at the time of maximum pollution in most cases, should also be determined. The location of the great sources of pollution and the distances through which the river flows from one to another are important data. Data as to the increase in pollution with the time are of value to form an estimate of the probable length of time until the stream must be abandoned as a source of water supply. These can be obtained by determining the increase in population, the increase in extent of sewerage systems, in manufactures, &c.

With this knowledge at hand we can examine the results of chemical examinations of the water, samples being taken from places judiciously selected and in considerable numbers at frequent intervals, and feel as though we could understand what the results mean and of what value they are in any particular case.

The subject of the biological analysis of water is a very new one, and it is difficult as yet to say how valuable it may be. I therefore place it last in importance, but I am disposed to think that our principal line for advance is in this direction and that in the future the methods of biological analysis will be improved and this manner of investigating water assume a high rank.

The world is very young in this matter and our theories do not fit all the facts. I have not attempted to give anything more than as brief a statement as possible of the work that has been done in this country from the

practical standpoint, and have let the theories severely alone for the present. The chemical analyses appeal more clearly to the eye than any results of inspections or counts of bacteria and I have therefore confined the statistical part of the paper to them.

I must beg your indulgence for the form and the fragmentary nature of the paper on the score of lack of consecutive hours and of enough of them to put it into good shape.

PHOTOGRAPHY APPLIED TO SURVEYING.

By G. W. Pearsons, Member Engineers' Club of Kansas City.

[Read March 3d, 1890.]

The subject of *Photography applied to Surveying* is one not as yet taught in our technical schools, and there are probably few who can write or speak on it as teachers; of these few I am not one.

Having had occasion to do some topographical work and having dabbled a little in photography as an amateur, I was interested in bringing them together by a work on the subject by Lieutenant Reed, U. S. A. To the engineer accustomed to the definite line given by his transit, the first idea of having the whole landscape on his table is likely to be received with mistrust, but when we recollect that some of the most important studies in astronomy have been forwarded very materially by photography, we may consider that in the much more accessible field of our work, it may be equally useful.

It may be assuming too much to consider any one here wholly unacquainted with the subject, but it can hardly be treated except by going over the ground in a rudimentary manner.

The focal length of cameras best adapted to this work being from 12 to 15 inches may be imagined to represent an eye of that diameter and should therefore show its objects somewhat more fully than the unassisted eyesight. The ordinary camera, however, has no means of determining exact locations, except relatively, and cannot be considered as in any manner dispensing with the transit.

The image formed on the sensitive plate represents a series of right lines passing through the centre of the lens from the landscape to it. If, therefore, the plate is in correct position it will give a mathematically correct copy, capable of direct measurement, and to a much greater degree of accuracy than would be at first imagined. The sensitive plate can retain an exceedingly accurate image of anything it gets a wink at, but it is indifferent to the circumstance of position, and it makes no difference to it whether it rests on a granite obelisk or the quarter deck of a mule.

To become useful for purposes of precision, proper regard must be paid to the position of the plate and camera. The plate must be truly vertical

and its edges truly horizontal. The first is of greatest importance, the last is important for the proper definition of the horizon and the connection of the plate with others.

The angle covered by the plate must be known, and it is of very material assistance to the work to be able to so direct the instrument that each plate will give the same lap on each edge. For this purpose the interval between the centres of any two pictures should be from two to three degrees less than the whole measure of the plate, not only because faults are likely to occur on the edges of the plates, but to afford means of accurately joining them by inspection of the similar objects shown on the edges of adjacent plates.

Engineers sought for more effective means of work than given by the plane table before photography existed, and even in its earlier stages made many efforts to utilize it. Now that the camera is so common an adjunct to the engineers outfit and so little trouble and uncertainty is found with its use, even by amateurs, it offers a help well worth utilizing.

Supposing that the camera is found to show 38° on the plate, by allowing 1° on each edge for lap, we have for each plate 36°, or five for 180°, which is as much as is generally needed for one station.

This is about as given on the plates shown here, but I believe I should decidedly prefer 5x8 inch plates with a useful angle of 30°, which would require one more plate for each 180°, but as these plates cost but one-half as much as the 8x10 and are almost always deep enough vertically, their lesser cost, lightness of transportation, and less liability to distortion on the edges of the plate on account of the lesser angle, will, I think, overbalance the added number of plates required.

These plates require that the centre be correctly located, both vertically and horizontally, as they must be measured by a scale of tangents from the vertical centre and horizon; in ordinary use the camera is focussed separately for each picture, but as differences of focus for landscape distances are very slight, the camera for this use is focussed on a distant object and marked, so that all pictures are taken with the same focal distance and can therefore be measured by the same scale of tangents.

In Lieutenant Reed's instructions, as I understand them, he provides for marking the plates by inserting needle points in the plate holder so that the points will make a mark in the film on the top, bottom and sides of the plates.

I do not see how this is practicable with an ordinary camera, though it may be with one if made as an instrument of precision.

In the first place each plate holder would require to be provided with points, making a very serious job to fix, say a dozen double plate holders so that they would correspond. Again, these holders hook onto the back of the camera and necessarily have some play, making, it seems to me, both a difficult and uncertain means of uniform register, to say nothing of the liability that some of the points may fail to make their mark.

I have substituted the following arrangement: The camera itself gives means of reaching within about ⅛ of an inch of the sensitive plate. By placing needle points at the top, bottom and sides so as to mark the ver-

tical and horizontal centres, their shadows are thrown on the plates and are sure to be alike on all plates as regards the position of the camera itself, no matter how the plate may stand in the holder or the holder on the camera.

The image of the needle is somewhat enlarged, but as the distance from the needle to the lens is perhaps 100 times that to the plate, the enlargement is not much and being uniform is not troublesome.

It remains to place the camera correctly. All my attempts to use the usual tripod have been failures—it is too light and the means of making uniform angles between the pictures and of insuring the leveling of the camera are too uncertain. I therefore made a table attached to the guard cap of the transit tripod, furnished with leveling screws, two levels and the edge marked into degrees, for convenience of making the pictures cover approximately equal angles. This being carefully leveled and having the stability of the transit tripod, enables a series of exposures to be made with a fair degree of uniformity, which is almost a necessity where it is required to join several pictures. By this means a long tangent scale can be used to cover any number of plates, care being taken to see that the centres of the plates correspond approximately to the centres of the corresponding tangent scales, and the whole read consecutively, which is much more convenient than a separate study of each plate.

It will be understood, of course, that to use such a scale the exposures must cover approximately the same angle, otherwise the centres of the places would not correspond with the centres on the scale. Exact correspondence is not necessary because the size of each degree varies so little from the next, that a slight displacement would not make any perceptible difference as it is only the difference in their sizes that is to be considered, and not the angular location otherwise.

Now, having our camera in order and as many plates as we want for the trip, we load up our camera and transit and with note book and a few cigars are ready for the field.

Proceeding to our starting point we place our heel carefully, turning upon it and looking wise in several directions to assure our assistants that we know exactly where we are starting from, drive a peg, put a tack in it with like scrupulous care and set up our transit, with this we take such notes and observations as will determine salient points in the photographs, by which they can be adjusted and placed, and in this, as in preliminary R. R. work, it will be convenient to read directions from 0 to 360.

We now take the transit off the tripod and put the camera in its place, commencing at the left of the field, having set it as we desire for the first plate we note the degree covered by the centre mark on the bottom of the camera. Suppose it to be 19 degrees and our camera to cover 35 degrees, our successive settings will be 54, 89, 124, 159, 194 and so on, and though any one of them may be slightly misplaced, for a rough setting like this is not a transit direction, the error is not cumulative and the note book by giving the direction of salient points in the different plates enables the tangent scale to be applied to the whole correctly.

Here it will be proper to remark that the person taking these plates

does not want anybody to help him or talk to him while he is doing it.

It is a very simple thing to take holder No. 1, fasten it to the camera with plate No. 1 towards the lens, draw the slide, make the exposure, replace the slide and change sides with the holder for the next view; it doesn't take more than a minute or so, and but a few minutes to take a whole set in regular sequence and all O. K. But let some interested or interesting party assist, and maybe you will forget to turn the holder for the second view—and take two on the same plate, or you may make an exposure without drawing the slide, or become so interested as to take the holder off the camera without putting the slide back. Or when you came to make an exposure find the cap is not on and the camera has been looking out all the time you were making the plate ready, and another one is spoiled, and in general you won't know till you develope your plates whether you have got a full set or not. The old notice of no conversation with the man at the wheel applies just as well to the man at the camera.

Proceeding to the next point a set of views is taken in the same manner, intersecting the first, the points of observation being known, these intersections determine any desired point in the field of view; the third station bears on the first two, the fourth on the second and third, and so constitutes a continuous triangulation, on which most points may be defined by three intersections. Any print determined by these intersections is also defined as to height by the tangent of its distance from the point of observation. The plates, therefore, give vertical as well as horizontal definition of the field, and with a degree of accuracy which will surprise the beginner.

In making these plates due care must be taken to so mark them that they will not get mixed. I have found that a steel point with which I could mark the number of the plate on the film before placing it in the bath is a means of making a mark which won't rub out and makes it easy to keep them in order.

Our plates being developed, the next thing is how to use them. For convenience we want positives, put together so as to form a continuous landscape; this is not strictly necessary, but is by far the most convenient.

I have tried silver prints, bromides, etc., but find common blue prints better than anything else I have found yet. The silver prints give finer definition, but can only be kept in place by mounting with its inconvenience and added liability to distortion. The bromides are very expensive and give no better definition than the blue prints. The blue prints are very cheap and with the negatives at hand for reference, if needed, answer a very good purpose.

In making transit surveys with a view to assistance from photography, such salient points must be located as will give the most comprehensive views. The engineer then takes to his drawing table not the isolated notes of his field book, but a comprehensive view of the whole area of his work, which can hardly fail to be both of interest and use.

The blue print map of the bend in the Missouri was made from the accompanying blue prints from negatives taken from Fifth and Bluff

streets in this city, the foot of Minnesota Avenue in Kansas City, Kansas, and some other points not represented.

Some of the plates are faulty, from the camera leaking light, which was not discovered till too late, as they answered the purpose, however, and I had not time to repeat them, the smoky condition of the atmosphere making it difficult to get good views, I used them as they were.

In making views in the vicinity of the city, good definition of distance can hardly be obtained in the fall of the year. This will, however, seldom interfere with such distances as will be needed in usual work. In the spring the air is clearer and better definition of distance can be made.

For reconnoissance the camera offers some pleasant features. The public are always anxious to know what an engineer is doing with a transit, but if he has a map of the county and an aneroid in his pocket, so that by fences or otherwise he can tell pretty near where he is, he is only an amateur artist making views of scenery, and the farmer is not snspicious that he wants to run a railroad through his corn crib: such pictures understandingly used may help to decide where a line will probably be best, so far as general features of the country is concerned, and many interesting and amusing incidents aud situations will place themselves on the plate (with a little help) and make the work less prosaic.

Progress is the order of the day. It is not long since the engineer who used a camera to take occasional or semi-occasional records of the progress of his work was rather putting on airs—the blue print and camera have come in very handily—so handily that it is not the engineer who uses them, but rather the one who does not, who is the exception.

If some chap tired of climbing the hills in San Francisco had not got up a cable road, we might be hanging on to bobtail cars here; if some other chap hadn't got tired of climbing stairs and got up an elevator, we should need more ground for our cities and should have conflicts of jurisdiction between this town and St. Louis—or some similar trouble—as it is the farmers still have some room left. All that helps to expedite our work is useful and this is one of the items. It will not, however, be likely to dispossess us of our transits very soon, though the engineer who becomes familiar with it, especially in such work as making close topographical surveys, will have a very great advantage of him who does not.

THE FUNCTION OF THE GOVERNMENT IN A PLAN FOR GENERAL IRRIGATION.

By George A. Brown, Member Engineers' Club of St. Louis.

[Read May 21st, 1890.]

The attention of the Government and the people of this country is being earnestly called to the necessity of providing some more complete and systematic method of dealing with the problem of the artificial distribution of water for the purpose of irrigation which is required for the agricultural development of the Western States and Territories.

Until very recently this work has been left almost entirely to individual effort, and has generally been limited to small areas. The endeavor to extend these areas of irrigation, and to accomplish a more complete distribution of the water available, has shown the advisability of combined instead of individual efforts, and especially it has made clear the fact that a water right under the present laws, is a very indefinite and uncertain possession.

It is the function of the Government, evidently, to establish the definition of a water right for irrigation purposes, so as to obtain a just apportionment of the supply, and also to provide for the economical distribution of the water; but differences of opinion have arisen as to the best means of performing this function.

One opinion affirms the possibility of making a satisfactory measurement of the quantity of water available for this purpose and then of subdividing it so that a title may be given to a certain quantity; which title shall be almost as definite, in regard to amount and location as that now given by the Government to 160 acres of land, by means of its system of land subdivision into townships and sections.

Another opinion is that a water right should only be acquired and maintained by the actual use of water. In other words, that a title cannot be given to the water itself, but that protection can be given by the laws to the use of water for the improvement of land or other property.

The present water laws and the customs of the country have been formed on this theory, and if made more definite, and supplemented by some special legislation might, it is claimed, furnish the protection required for the works necessary in reclaiming the arid districts by irrigation.

There is a radical difference however, between the use of water for irrigation and its use for power or for navigation; which two uses have been the principal ones, heretofore, requiring protection.

Irrigation is an absolute use of the water, diverting it entirely from the natural channels; whereas the development of power or navigation,

does not really use the water but rather uses the fall of water or its buoyancy; and the title to such use might properly be considered as belonging to the land through which the water naturally flows.

But the attempt to protect the absolute use of water as in irrigation, without defining the amount that one individual may use, or the place from which it may be taken; without, in fact, first giving a title to the water so used, will lead, it seems to the writer, to one of two results: either the great system of irrigation which may be developed will be owned by a few men of large capital, who, if not also the owners of the land supplied, will control the distribution of the water to those owners; or else, a large percentage of the lands will not be reclaimed, and the waters will be wasted through a separate and unscientific method of distribution.

This appears from the condition, that the water is, in the first place, free to whomever may take it, and wherever capitalists can see that it is valuable, they will be able to take possession of it because they have the means of developing its use. And moreover, any or every water right may be disputed and become a subject of litigation, since the title lies, not in the water, but in the use of the water, and that may always be disputed, whether rightfully or not, and—to use an expression of the mining districts—the claim may be jumped; with this advantage over jumping a mining claim, that it is not necessary to go on the land in order to take the water from it.

This opinion is the result of the writer's observation and experience in several different sections of the country; in some, capitalists owned works of distribution, in others almost all claims were in dispute and but little irrigation work could be accomplished, and even in some of the districts where the property owners had organized under irrigation laws to carry on the work jointly, an expense of double the actual cost of the works had to be allowed for, to purchase claims for water rights, and for legal expenses to fight other claims.

To the writer it does not seem possible to define what shall constitute a right to the use of water, in general terms. but that the solution of this problem is to be reached by measuring the water and by apportioning the available supply to the land upon which it can be most economically distributed, and from which the best returns can be obtained.

No authority but that of the general government could make such a determination, but, as the original owner by right of purchase, or of discovery, or of gift from the original thirteen states, it seems to me that the general government has the necessary powers to define and sell, with each piece of land disposed of, a title to a certain amount of water, to be taken from the natural supply under certain conditions.

If this is granted, then the question of water right ceases to be a legal question and becomes an engineering one, to be determined definitely only after scientific examination and surveys of the country, which will measure the amount of water and determine the most economical points for the location of distribution works, and will finally select the lands upon which it shall be lawful to use this amount of water.

The able director of the United States Geological Survey, Major J. W.

Powell, has, as you all know, been the leader in the thought which forsees the necessity of such surveys and examinations, and he was able, during the past year, to direct the work of a preliminary survey to determine roughly the resources and possibilities of the arid country.

This survey, though of course not minute enough to furnish a definite answer to just what lands the available water could be made to supply, or the manner in which it could be done to the best advantage, and economically, has shown that the practical solution of these questions is possible, and that therefore, under a policy of government apportionment, a water right could be made a definite possession, and the farms, the orchards, the homes, developed under its use, would no longer be in constant jeopardy by the excessive appropriations of the life giving fluid by some more powerful neighbor.

The question may now be asked as to what action is necessary by the government to put such a policy into life.

In order to establish systematic and complete irrigation, it has been asserted that the government would have to assume some form of paternal control over the works and the occupations of the people.

Should the government construct the necessary works of distribution and maintain them it might easily come to hold absolute control over the people served, such as now the private owners of such works but too often assume.

But neither government ownership of the works, nor direct control of the distribution, seems to be necessary, and it is certainly far from being desirable.

It would probably be necessary for the government to assume an ownership over the water as a possession distinct from the land, in which it lies, or through which it flows: but only for the purpose of selling the rights so assumed, as it now sells the title to its land; that is, with the aim of distributing it among actual users in as equitable manner as possible.

It would be necessary for the government to have a survey made under competent direction for the purposes previously outlined. Such a survey has been estimated to cost five millions of dollars. It may cost more than that, but it will not approximate to the expense already undergone in measuring the land, much of which is valueless without the water rights.

And further, it would probably be necessary for the government to provide laws, enabling the corporate organization of the buyers in the different natural irrigation districts, which the surveys would show to exist, and granting charters, defining their special powers.

In the crowding together of great numbers of people into cities, life is maintained under artificial conditions, and in order to make such conditions not only as nearly perfect as possible, but even to make them endurable, it is necessary for the public to assume certain rights of control over individual actions and works; as, for instance, over the erection of buildings which, through bad design or poor construction, might become dangerous. Also, to assume the designing and construction for the individual and at his cost, of works for special purposes, that are required for

public comfort or convenience; such as sewering works, street paving and lighting.

These rights of the public are obtained by incorporating the town and obtaining a charter from the State government, which defines its powers.

The reclamation of the arid lands is a similar attempt to maintain life under an artificial condition, but with this important difference that the function of a city government is to maintain the general conditions of life. It has to do with the *environment* of life and of business: whereas, the function of the government of an irrigation district would be to establish and maintain the equitable distribution of the source of life and wealth to the district. It has to do with the *means* of life and of business, and therefore its powers should be most strictly defined, and the rights of the minority carefully protected. Herein lies one of the strongest reasons for the government's making a definite distribution of rights in the water supply and designating in the charter of each district the amount of water to belong to each acre, the total amount of which shall be as close to the actual amount available for the district as is practicable.

The corporation should have the power to levy and collect assessments, or to sell bonds and to construct works, necessary to supply the water from the natural sources,—such works as reservoir and diverting dams and supply canals; and should have various powers of control,—the discussion of which is beyond the scope of this paper.

But there is one important function of the general government in relation to the organization of these districts to which attention should be called, and that is, in regard to limits of the districts and the assessment of the public lands. The object to be gained in organizing these districts is to establish complete systems of irrigation.

To that end the government should fix the limits of each district in conformity with the natural configurations of the country, as shown by its irrigation surveys.

The organization of the district is to be made by the land owners, but it would be unwise not to allow such an organization until the government had sold to individuals all the land in the district; therefore, it should provide that when a certain number of people had become or had declared their intention of becoming owners and had taken the necessary preliminary measures, the district might be organized and the necessary works carried on, the government lands in the district being assessed similarly with the other lands, and whatever assessments were paid by the government should be added to the price of the land when finally sold.

The legal status of such irrigation districts is properly established by the state legislature, but the states have not the power to include the government land in such districts, or to levy assessments or taxes on such land, and therefore, before complete irrigation districts can be formed, the general government must make these necessary provisions.

In the scheme outlined above, the government would be protected against any possibility of over-assessment by the district since the government itself defines what shall be the limits of the district, and makes the

apportionment of the water rights; which apportionment is made the basis of the distribution of the taxes necessary to meet the cost of building the various works for supplying the water to the land.

Such a policy inaugurated by the government would lead to the reclamation of the maximum amount of the arid lands, and there would yet remain, in the possession of the government, those lands for which there was no available water supply, and the mountainous districts, the land of which is not economically tillable, and is therefore, not granted any rights in the water supply, but would be reserved as a gathering ground for the water to supply the tillable land.

The irrigation districts, depending so entirely as they would, on such gathering grounds, should be granted sufficient guarantees that their use for that purpose should not be interfered with.

It has been suggested that the absolute ownership of such gathering grounds be granted to the irrigation districts supplied from them there, but such grants might furnish an opportunity for land grabbing where these mountainous districts are covered with valuable timber, and moreover, for the reasons stated previously, the powers of the irrigation districts should be limited strictly to the purpose for which they are organized.

It therefore would seem a better plan for the government to retain its title in such lands, and to sell to individuals the use of them only, and for such purposes as they may be valuable, as pasturage, mining or quarrying, timber raising, and sites for developing water power, provided that there is no interference in anyway with the use of these lands as a gathering ground, nor interference with the works for obtaining the storage of the water and its delivery to the irrigation district.

To the irrigation districts should be granted free right-of-way for all reservoirs, for diverting dams, canal lines, and so forth, and they should be granted the right to prosecute suit for the ejectment by the government, of any persons who had bought the use of land from the government, and had abused the rights of the irrigation district in the ground, or had damaged their works.

This would be a sufficient guarantee that the efficiency of the gathering ground should not be diminished, and incidentally would settle the question of the rapid destruction of timber resource of the country; since the wholesale destruction of the timber from the mountains could easily be shown to be a detriment to their use for collecting and retaining water.

So far, I have attempted to discuss only the natural functions which the government could assume in developing an arid country. The assumption of such function at the present time, is complicated by the fact that much of the most valuable land has been sold, the country settled, and rights assumed, without regard to any such relations with the general government. In many districts this settlement has gone so far that it would not now be advisable to interfere directly to obtain a readjustment. But in the great majority of the districts, so little actual settlement and use of water has been made, that there should be little difficulty in effect-

ing an adjustment between the rights acquired under present customs and those granted by a readjustment.

The more important subject for discussion now is that of the practicability of measuring the water that can be made available for irrigation. This involves a measurement of the waters collected on this Western country, *not* as they now flow, but as they can be made to flow; and a survey and mapping of the manner of their distribution, not in their present natural channels, but in suitable lines for artificial channels; in fact, the formation of plans for a complete redistribution of the waters on this part of the earth's surface.

A portion of the waters can be brought under absolute control by impounding them; and just what reservoir capacity can be economically obtained in each district must be determined.

These are not theoretical questions, but are practical ones and can only be presented for discussion by the aid of maps and estimates based on actual surveys, or at least, by descriptions of the country, based on personal examination.

It was the writer's good fortune to be connected for a short time last season with the irrigation survey work of the government in Western Nevada. A short description of that work, and of the country examined, is all the contribution he is now able to offer toward a practical discussion of the subject.

At Silver Mountain,—or just north of that volcanic peak,—the Sierra Nevada range seems to divide; one spur goes off a little the east of north, and forms the divide between the Walker and Carson Rivers. The main range, the general direction of which is west of north, splits into two ridges, of about equal height, between which lie Lake Tahoe and the valley in which the Truckee River rises. This river flows northward from Lake Tahoe for about twenty miles to the town of Truckee, where the drainage from Mount Stanford and the Donner Lake region joins it.

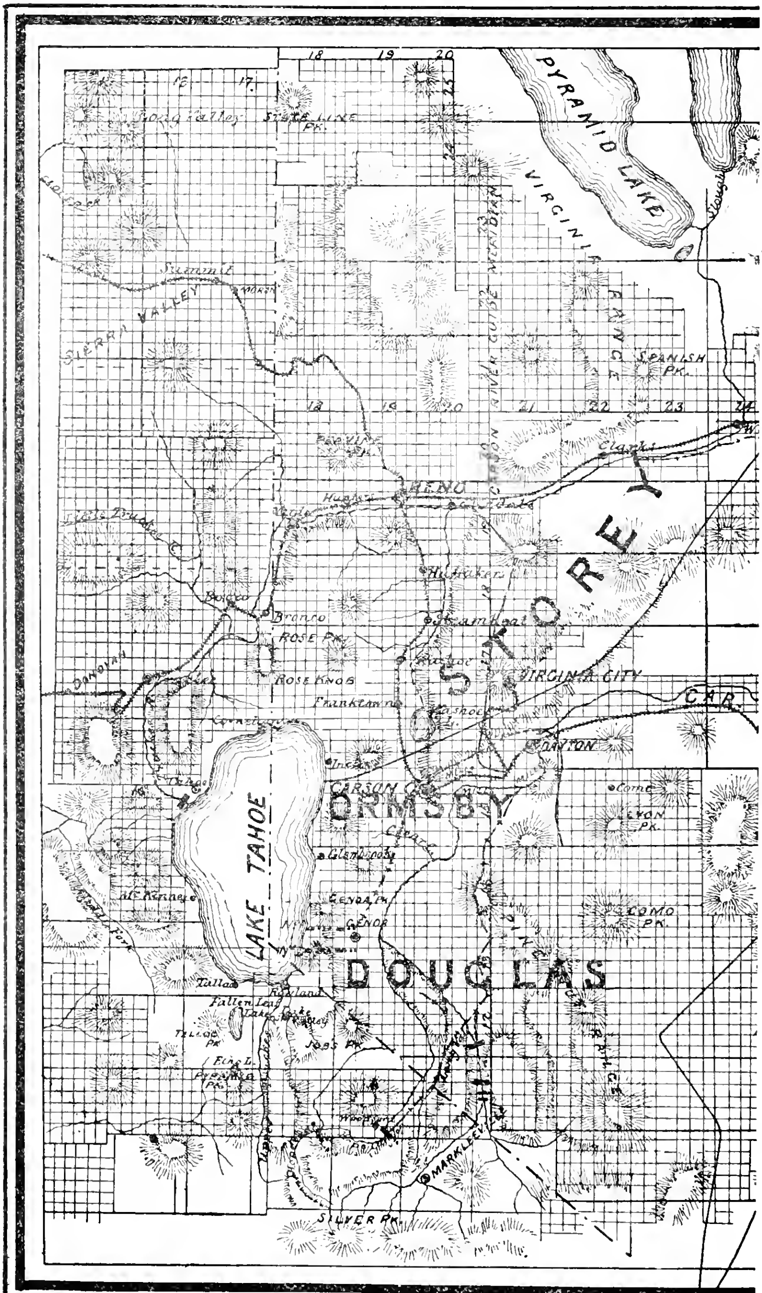
From the town of Truckee, the river flows easterly past Reno, and as far as Wadsworth, where again it turns northward and empties into Pyramid Lake. The Truckee River is of the character of a mountainous stream throughout its entire length. There is little land available for agriculture near it, except about the town of Reno.

It is about a hundred miles long; connects two large mountain lakes, and receives the drainage from the summit of the Sierra Nevada mountains, and the spurs of the main range between which it flows, while it has very little agricultural land naturally tributary to it.

But southeast from Wadsworth, stretches the central plain toward which the waters of a large part of the Great Basin tend.

If it is possible to economically divert the Truckee from its northern course to a southern one at Wadsworth, a large supply of water would be made available for this land.

It is especially desirable to bring the waters of the Truckee on to this plain, because while they cannot be used for irrigation on any other land, the water of the two streams which now reach the plain, namely, the Humboldt and the Carson, can be used to great advantage on the lands of


PYRAMID LAKE
STATE LINE PK.
VIRGINIA RANGE
SIERRA VALLEY
Summit
SPANISH PK.
RENO
Clarks
STOREY
Huffakers
Steamboat
Franktown
VIRGINIA CITY
DAYTON
CARSON C.
ORMSBY
LAKE TAHOE
Tahoe
Glenbrook
GENOA PK.
GENOA
Como
LYON PK.
COMO PK.
DOUGLAS
McKinney
Tallac
Fallen Leaf Lake
JOBS PK.
MARKLEEVILLE
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Donovan
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Verdi
Hunters
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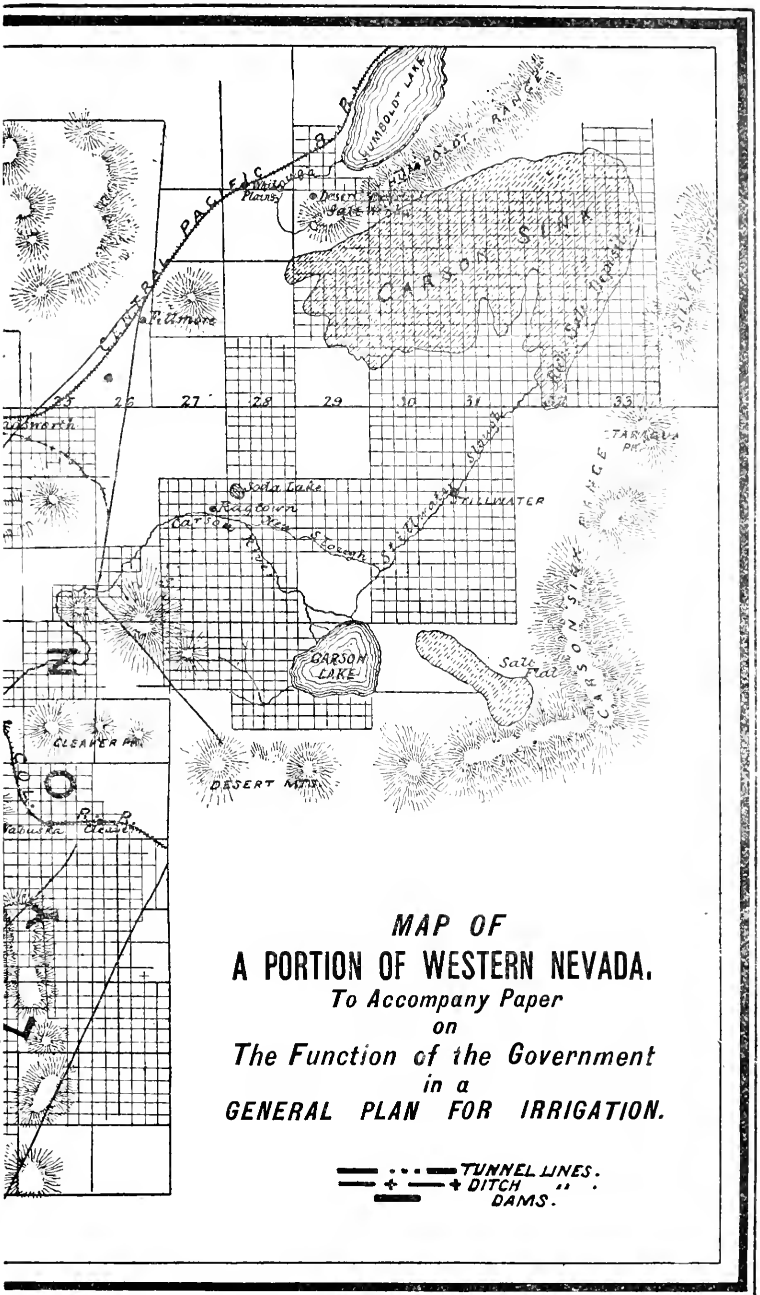


MAP OF
A PORTION OF WESTERN NEVADA.
To Accompany Paper
on
The Function of the Government
in a
GENERAL PLAN FOR IRRIGATION.

their own valleys, and the Walker River, which is the fourth stream that approaches this central plain, although its waters turn away to the south before reaching it, as those of the Truckee turn to the north, has also much agricultural land directly tributary to it, and the improvement of these valleys would tend to lessen the supply even now reaching the plain.

The preliminary examination of these four streams and the regions adjacent to them, was the work assigned to our division of the irrigation survey. To accomplish this, one party was stationed at Wadsworth to work on the problem of diverting the Truckee, as already outlined, another party was stationed near the town of Truckee to determine the storage capacity that could be made available in the Donner Lake country and the region north of the Truckee River; while the party of which I was in charge, had assigned to it the work of examining Lake Tahoe as to the possibility of increasing its storage capacity, and of obtaining a more direct outlet of its waters toward the central plain than the circuitous route of the Truckee River, by means of a tunnel through the divide between Lake Valley and the valley of the Carson River, which should connect the lake with the Carson River, and thence almost directly to the central plain; also to determine the storage capacity of the region about the headwaters of the Carson River.

It was not attempted, during this first season, to include the valley of the Humboldt, or of the Walker.

Of the surveys made about Lake Tahoe, I will give but a brief description, because the conditions which may be utilized there are of isolated occurrence, and therefore not pertinent to a general discussion, whereas the conditions studied in the work on the Carson River, are the general ones to be met with all over the country.

Lake Tahoe is about 20 miles long, by from 8 to 12 miles wide, containing say, 200 square miles, or 120,000 acres. On examining its outlet, it was found entirely practicable to build a dam that would raise its surface 10 feet. In fact, a dam already exists, though somewhat out of repair, that will raise it 6 feet.

With the present outlet, the surface of the lake varies in elevation but little at the different seasons of the year; often not more than 6 inches, and the greatest difference between high and low water mark, as shown on piles that have been driven a number of years was four feet.

By controlling the outlet, and closing it entirely for a hundred and forty days in each year, and by building a dam 10 feet above the present surface, and constructing an outlet available to a depth of 20 feet below this surface, thus giving an available storage capacity of 30 feet in depth, to furnish a supply during a number of dry seasons, it would perhaps be possible to obtain a yearly supply of 4 feet of depth to be taken during the 200 days that irrigation is required, or say 20,000,000,000 cubic feet of water a year. This would irrigate 300,000 acres of land, and would require a channel of at least 200 square feet of cross section, with a fall of five feet to the mile, to carry it in 200 days.

The principal work that I did at Lake Tahoe was to run three lines

across the mountains on the eastern side into the Carson valley, in order to determine the shortest line for a tunnel through this range. The result of this work showed two lines of about the same length; that coming into Carson valley opposite Genoa was four miles long, and the other line, about three miles south of Genoa, of nearly the same length, but with the advantage of about 1200 feet of low ground on the Lake Tahoe end, which could be made as an open cut. Estimating the cost of a tunnel of that length and of 200 feet of cross section at one hundred dollars a lineal foot, the total would amount to two million dollars; or when distributed proportionally to the 300,000 acres of land for which it would carry a sufficient supply, it would amount to but six and one-third dollars per acre.

But the greatest results could be obtained from the power that would thus be made available.

The elevation of Lake Tahoe is 6,200 feet above sea level; whereas that of the Carson valley at Genoa is only 4,800 feet, so that at the Carson valley end of the tunnel there would be a fall of some 1,400 feet, and the power that could be developed by utilizing this, would be sufficient to run machinery of over ten thousand horse-power for the 200 days that the water could be used.

Now, Genoa is but twenty miles from Dayton, where the mills for the Virginia City mines are located, and is but eight miles from Carson City; and were these cities required to obtain their water power from this source instead of from the Carson river, it would be no great hardship, and the Carson river water would be available for irrigation throughout the entire length of the valley.

In order to understand the plan for the surveys made on the Carson river, a short general description of the valley will be necessary. The valley itself, starting from near the State line, extends northward for about thirty miles to near Dayton, and varies from six to fourteen miles in width. Genoa is situated on the western side of the valley near the middle, north and south, and from there south, the western side of the valley is the lowest; the land on the east side rising in one or two benches, which would make that the most available side from which to distribute the waters for irrigation, but north from Genoa, there is quite a bench on the west side of the valley. The Carson river divides into two branches just south of Genoa, called respectively, the East and the West Fork. The East Fork is the larger; it rises on the northern slope of Silver Mountain, and at Markleeville, the county seat of Alpine county, California, it has become a good sized mountain stream. From there, for twenty miles down to its entrance into the valley proper, it follows a tortuous and generally narrow defile of the montains, which in several places widens out into flats from half a mile to a mile wide. This fall will not average more than twenty-five feet to the mile in this distance.

On the West Fork the valley extends some five or six miles farther south than it does along the East Fork, and at the head of this arm of the valley the West Fork enters almost at right angles from a steep and rocky walled canyon of the Sierra Nevada Mountains.

The sources of the West Fork are along the crest of the range near the place where the Sierra divides to form the valley of Lake Tahoe. It flows northward along this crest for several miles with little land above it, except the peaks and the crown of the ridge. On this portion of the West Fork are two valleys; the one called Faith valley is not much over a mile long by less than half a mile wide, and has very little slope in the direction of its length. The other—Hope Valley—is about four miles long by from a half to three-quarters of a mile wide and has a slope of but twenty-five feet to the mile.

From Hope Valley, the West Fork turns east and flows down Hope Canyon into Carson Valley as before mentioned.

Between the West Fork from Hope Canyon north, and the East Fork, there is a double chain of elevations between which lies what is called Long Valley. There is little water naturally flowing down this valley, but a portion of the water of the West Fork has been diverted at the mouth of Hope Canyon and brought into this valley. It opens into the Carson Valley proper at the same point as does the East Fork.

If I have succeeded in this description of the head waters of the Carson, you will see that the natural conditions were favorable to the object of diverting as much of the water on to the bench lands on the east side of the valley as possible. The East fork brings the most water, and through Long Valley, the West Fork may be made to join it.

Our first surveying work was at the junction of Long Valley, and the East Fork defile with the Carson Valley, the East Fork being examined for a distance of five or six miles up. It was found that for the first two miles up from the valley, the defile was very narrow with rocky walls rising to a height of 200 feet, and had a slope of nearly 40 feet to the mile. This was discouraging, but on the next three and one half miles, a slope of but little over 20 feet to the mile was found, with a wider channel, and a strip of land bordering the stream; the rocky sides receding so that in several places there was a width of over a half a mile on the bottom. The first dam, therefore, could not be located lower down than the point two miles above the outlet. Here a suitable location was found, with a cross section of 150 feet on the bottom, and 450 feet at a height of 100 feet above the stream.

The bench land, on which it is desirable to take the water, is a little more than a hundred feet higher than the East Fork, where it enters the valley. In order to reach this, a supply canal would have to be built up the side of the canyon, and at the site selected for the first dam, it would still be some 40 feet above the bottom of the stream, if given a grade of 10 feet to the mile. On surveying this canal line, it was found to come on most difficult ground in many places on the sides of almost perpendicular rocks rising to a height of from 25 to 100 feet above it.

The survey was now directed to Long Valley, and it was found that a canal line could be carried up the sides of the valley much more easily, but would of course have to be carried across the East Fork on an aqueduct. A good site for a dam was found about a mile and a half up this valley, at which point, the canal line was about 50 feet above the bottom

of the valley. A dam at this point, 100 feet high, would form a reservoir two miles long by over a mile wide; and it was found that a tunnel, not over a quarter of a mile long would connect this reservoir with the first one suggested on the East Fork, so that those waters could be brought into the Long Valley reservoir, and from there, carried out to the bench land with much lighter work than would be required on the East Fork canal line.

A survey was now made up through Long Valley to a connection with the West Fork in Hope Canyon at a site selected for a diverting dam of 20 feet in height. No difficult work was encountered on this line. The party was now transferred to Hope Valley, and a survey made to determine its capacity as a reservoir, which showed it to be ample to store all the water that could be probably collected above it. We then expected to examine the East Fork further up its course, but were suddenly called in from the field, as the appropriation for the work was exhausted.

This left the work in a very unsatisfactory condition – the study of the reservoir capacity of the region not completed, and no surveys made to determine the amount of land available for agriculture in the Carson Valley. However, the survey was only intended as preliminary work, from which only approximate estimates might be made, and the possibility of performing the work be shown, and this I think has been accomplished.

ASSOCIATION OF ENGINEERING SOCIETIES.

PROCEEDINGS.

WESTERN SOCIETY OF ENGINEERS.

SEPTEMBER 3RD, 1890.—The 272nd meeting of the Society was held at its rooms, Wednesday evening, September 3, 1890, at 8 o'clock, p. m., President L. E. Cooley in the chair, and some 80 members and visitors present.

The minutes of the previous meeting were disposed of and the Secretary made a report of the meeting of the Board of Directors.

The following members were elected: Rudolph B. Bourland, C. F. Theodor Kandeler, Edward L. Abbott, Charles H. Miller.

The following applications for membership were received: Chas. E. Hopkins, Chas. V. Weston, Theodore Starrett, Jacob A. Harman, Henry E. Gamble, Ira Smith Dunning, L. C. B. Holmboe, Chas. J. Morse, William E. Miller, Ridley H. Lawrence, Harold A. Boedker.

The following is an extract from a letter from Mr. Chas. Hansel, Consulting Engineer, Railroad and Warehouse Commission, State of Illinois, Springfield:

"Would like to know if the Society has ever had any papers on the subject of Safety Appliances for Railroads. Our Commission has instructed me to make exhaustive report on same for this years' report, and I am desirous of gathering data and opinions.

If no paper has yet been read on this important subject, would it not be a good topic for some member conversant with the requirements.

Our board do not hope to solve the much debated problem of uniformity in safety appliances, but are seeking light on the subject."

The President called attention to the importance of the matter, and hoped members would adopt the suggestion, and accept it as a request from the Society for papers on the subject.

A letter was also presented from Mr. Benezette Williams, Chairman Board of Managers, Association of Engineering Societies, submitting the following amendments to the articles of Association to the Society for ratification:

It was ordered that the amendments be printed herewith to be ready for disposa by vote at the October meeting of the Society.

AMENDMENT I.—Upon application to the Board of Managers by any Society member of this Association, the Board shall have power to lay before the several societies any question of scientific, technical or professional interest, with the request that each Society investigate the subject named, and report upon the same to the Board by a certain date. Upon the receipt of the several reports the Board shall formulate a general report embodying the facts and in accordance with the general sense and tenor of the local reports, and this report shall be published in the JOURNAL as the sense of the Association.

AMENDMENT II.—The Board of Management may make recommendations on any subject affecting the policy of the Association, or the mutual relations of the participating societies, and submit the same in the form of resolutions to be acted upon by the several societies. If these resolutions be adopted by two-thirds of the societies, they shall become the law of the Association, and binding upon all participating societies.

The President informed the Society that the Geological Society was very desirous of the cooperation of our Society in its work, and intended sending circulars inviting our members to join their body.

A letter was also read from Mr. W. D. Clark, of Springfield, calling attention to the work already done by the government in the way of surveys and triangulations, and suggesting that in regard to a topographical and cadastral survey of our ow

state, our Committee should be ready to agitate a presentation of the matter at the coming session of the legislature.

In the matter of reports of Standing Committees, Mr. Richard P. Morgan, Chairman of the Committee on the Chicago Terminal Facilities, etc., presented the following:

"In consequence of the absence from the city of several of its members during the summer months which immediately followed the appointment of the Committee on Terminal Facilities, etc., it has not hitherto been practicable to meet formally and enter upon the duties assigned to it.

At the request of a majority of the Committee, its Chairman has called on nearly all the Presidents and Managers of the Railway Companies, to explain the purpose of the Society in appointing the Committee, and also to solicit pecuniary assistance to defray the necessary expense in the preparation of such a report as the Society has in contemplation.

Many of the railway officers were absent during part of the summer, but after repeated calls most of them were seen.

They expressed a decided interest in the subject, and have already pledged a considerable amount of money and other valuable assistance.

There is no good reason to doubt that the needed amount of money will be contributed, therefore it may be expected that the Committee will at an early date enter actively upon the work before it."

Business being disposed of the President said: Gentlemen:—The regular order of the evening is the World's Fair Site. The matter has been before the public for several months. I think, however, if they give the Engineers as many days to discuss it as months have been taken by the people in charge of this matter, and allow them to appoint a committee to examine into the thing, they would have reached a conclusion. The Society is to be congratulated on the fact that one of its members, and a past President,—a gentleman who held the office which I now have the honor to hold, two seasons ago, has been made Consulting Engineer of the World's Fair Committee. In looking over the matter to-day, it seems to me that nothing has been decided upon in regard to what kind of a Fair we are going to hold in this city. A conclusion should be reached on that soon,—if it has not been reached, and then there are general ideas,—general plans to be prepared, which we probably cannot prepare in 90 days. After that there are detailed plans to prepare,—a great many constructive details. The men in charge will have to be very lively if they handle this inside of six months, and if the contracts are let and buildings begun in 90 days after that, it will be expeditious. As I said, we are not here to discuss the matter professionally. We are not likely to reach any conclusion. But discussion means progress, and difference of opinion will bring out those differences which have to be investigated. The subject is open for discussion.

MR. ISHAM RANDOLPH then presented the paper which was printed in the September issue of the JOURNAL OF THE ASSOCIATION of Engineering Societies.

MR. RICHARD P. MORGAN followed, with remarks printed in the September JOURNAL.

GEN. FITZSIMONS:—I reluctantly coincide with the views of Mr. Morgan. Reluctantly, because the selection of the site of which he speaks—Garfield Park—takes the whole business out of the province of engineering. That site is already prepared—prepared by nature. It is a most admirable one. Mr. Randolph's arrangement of the Lake Front meets with my approval, of course, and I want to bear evidence to the fact of the possibilities of improving that site in the manner that he speaks of. I think he has been very moderate in both price and time. I am quite certain, from some calculations that I have made on it that the time can be greatly reduced, and the amount of money that the Lake Front will cost, will be much less than Mr. Randolph puts it. While Garfield Park is the fittest place, in my humble opinion, for the establishment of the Fair, the Directory has not seen fit to take that view of the case, and have submitted the Lake Shore as a primary position, with Jackson Park for the overflow. It seems to me that a body of men from whom so much is expected,—leading citizens of this great city of Chicago, can scarcely retract or withdraw from that position. The legal impediments, which they stated might prevent their offering the Lake Front have been removed, and they are standing now upon the question of expense; that is, they are seeking to find a second party who will remunerate them for any expenditure that they may make. They already have the assurance of the city of Chicago that if their ownership of the land is confirmed, that the money expended will be returned to the Directors. They also ask that the Illinois Central give them the same assurance. I think they are asking too many guarantees. I think that the expenditure of a million or two dollars, if it were only in keeping their word to the great national representatives, would be well invested.

In reply to a question General FitzSimons further said that if the breakwater were very carefully constructed the sand filling would meet all requirements, without any piling, but that clay would necessarily need piles for the foundation of the buildings.

PRESIDENT:—We have heard from two sites. I should like to hear somebody speak on the merits of the other sites. I should like to get them all before the meeting. Who will speak for the North Shore? Any Jackson Park or Washington Park men here?

MR. WAITE:—I am sorry to be compelled to differ with Mr. Morgan and Gen. FitzSimons. My idea is to take what we can get of Mr. Randolph's plan—making up the balance with the West Side of Jackson Park, the center of Washington Park and the Midway Plaisance, which I think we can get. The 200 acres from the West Side of Jackson Park need no filling. Midway Plaisance does not need any improvement. The site of Washington Park is already improved, and there we could get 120 acres. That is my idea of a site. This site has been tendered. My impression is the Park Commissioners will give Washington Park, provided the buildings are not put up where the land has been improved. In that level portion in the center there will be no objection. That, gentlemen, is my site.

MR. WALLACE:—I agree with Mr. Randolph. I have had considerable experience in bringing in sand into the city, and I will simply corroborate his views. I agree with Mr. Waite as to the South Side site in connection with Mr. Randolph's Lake Front. In regard to what Gen. FitzSimons says in relation to sand, there is no question but what that would be the best filling, and it could be made impervious. The sand foundation would be perfectly reliable, and would need no piling. Mr. Randolph made a suggestion that during the course of this filling, the buildings could go ahead along the Lake Front. That could be done in two ways—by the construction of coffer-dams around the site of the buildings, or by the making of the Illinois Central breakwater on the outside a coffer-dam, and pumping the water out of the entire site, and then filling in directly from the tracks. While it would be a great deal quicker to fill in the entire area at once, and use the water that is now there for the distributing of the sand, still if it is necessary to start the foundations of these buildings, it could be done inside of coffer-dams. I have had a large experience with coffer-dams on the Mississippi River, from 1870 to 1876. I wish to add further that in our office we have made calculations as to filling in the Lake Front, and our estimates are inside of the figures he has given here to-night.

MR. T. T. JOHNSTON next followed with a paper. See September JOURNAL.

MR. GUTHRIE:—I listened with a great deal of interest to Mr. Randolph's paper in regard to filling of the Lake Front. Any engineer who is conversant with the supply and quantity of sand available, the facilities for moving it to the Lake Front, and moving it in time, would readily dismiss any doubt of accomplishing the work necessary for the Exposition. It does not seem to me necessary that all this work should be completed before building is commenced. It might be so arranged that the buildings could be commenced within very few weeks after the filling was commenced. It seems to me that it promises more for receipts than any other site,—it is more available, with some qualifications which I will name hereafter. The objections in regard to drainage which Mr. Johnston has made against the different sites, are perhaps reduced to a minimum at that point. The sewage will be discharged virtually into the mouth of the river, and if we are fortunate enough not to have a cess-drain for it, send it down the Ills. & Mich. Canal. The estimates for the cost of filling are within bounds, but there is one question which troubles me, and has all the time, and that is how can we conduct the World's Fair on the Lake Front without interfering with the business of Chicago? That subjeet is the serious objection with me, and the only serious one against the Lake Front when the legal difficulties are removed—which I understand are now virtually removed. I am strongly in favor of the Lake Front, in so far as it can be used, with Jackson Park and Washington Park for the overflow.

MR. LUNDIE:—It seems to me that our problem is not the question of the World's Fair site from an æsthetic point of view, nor from a point of view as regards the question of commerce in the center of the city, but from an engineering standpoint. There are one or two points, brought up first by Mr. Randolph, and then by Mr. Johnston, which I would like to call attention to. In the first place, Mr. Randolph makes calculations on filling the Lake Front to a height of five feet above city datum. Mr. Johnston is six feet above city datum. As I understand it, one of the principal objections to Jackson Park was the difficulty of draining it. It seems to me the draining of this area would be very much more difficult. During the time of holding the World's Fair is the time of greatest high water. High water has been known in Lake Michigan as high as 5.6 feet above city datum. It would be a most unfortunate thing if we should build the Lake Front as high as five feet, and should have high water, say 5.6 feet. Regarding the drainage at Jackson Park, I happen to know about that district, for the reason that I have been called on to design a drainage system for about 600 or 700 acres immediately south of the proposed World's Fair site. The method was simple enough. It was simply a matter of running the surface water into a well and forcing it into the lake, and I was surprised in making up an estimate in conjunction with the Superintendent of Sewers here, when I obtained figures on different pumping engines, and found that 600 acres could be drained for something like $125,000 to $150,000, which is certainly not a very large expenditure, so it seems to me that the question of drainage is not a very great bugbear after all, as far as Jackson Park is concerned.

PRESIDENT L. E. COOLEY closed with a long discussion, which was also given in the September JOURNAL.

MR. RANDOLPH:—The streets south of Van Buren street, running east and west, are comparatively free from travel at this time. With the World's Fair located on the Lake Front, as is now proposed, we should have eighteen east and west streets

leading into that ground, affording ample opportunity for ingress and egress. I have made some calculations on this subject. Suppose we devote one sidewalk, average width eight feet in each street, to the people moving in one direction,—and suppose the people to be moving at say two miles an hour. Allow nine square feet as the space occupied by each person. We can move over those eighteen thoroughfares, employing one sidewalk, 161,000 every hour in the day. In your remarks you stated that the people going to this fair, would go up in the morning, say nine or ten. That is after the hour at which the busy people of Chicago have gone to their duties,—the workers, the men who carry on the great enterprises of Chicago, are by that hour in their counting-houses and shops. They are not clogging the streets. The people who go to the fair are not standing gazing in the street,—the shop windows have no attractions for them. There is something they have started out to see, and they are going to see it, and they are not going to loiter along the streets to get there. They will be starting out in the afternoon, say between four and five o'clock, to get to their homes again. The crowd in Chicago don't begin to go until that hour. Then, as regards railroad facilities, this site is within walking distance of every railway in Chicago. Not a single railway would of necessity have to build another mile of track to have its depot at points easily accessible to the fair.

This practically closed the discussion and meeting, the President suggesting that should the matter not be disposed of before the next meeting, the Board of Directors might bring it up again.

ADJOURNED.

JOHN W. WESTON, Secretary.

BOSTON SOCIETY OF CIVIL ENGINEERS.

SEPTEMBER 17, 1890.—A regular meeting was held at the American House, Hanover street, Boston, at 19:45 o'clock. President Herschel in the chair. Thirty-one members and five visitors present.

The record of the last meeting was read and approved.

Messrs. Fred V. Fuller, Edward L. Ross and James H. Stanwood were elected members of the Society.

The President submitted the following amendments to the articles of Association of Engineering Societies which had been adopted by the Board of Managers.

AMENDMENT I. Upon application to the Board of Managers by any Society, Member of this Association, the Board shall have power to lay before the several societies any question of scientific, technical or professional interest, with the request that each society investigate the subject named, and report upon the same to the Board by a certain date. Upon the receipt of the several reports, the Board shall formulate a general report embodying the facts and in accordance with the general sense and tenor of the local reports, and this report shall be published in the *Journal* as the sense of the Association.

AMENDMENT II. The Board of Management may make recommendations on any subject affecting the policy of the association or the mutual relations of the participating societies and submit the same in the form of resolutions to be acted upon by the several societies. If the resolutions be adopted by two-thirds of the societies, they shall become the law of the Association, and binding upon all the participating societies.

The amendments were discussed by Messrs. E. W. Howe, FitzGerald and Tinkham. Mr. Albert H. Howland raised the point of order that the amendments were not properly before the Society. The President decided that they were properly before the meeting and Mr. Howland appealed from the decision. By a vote of 11 to 5 the decision of the chair was sustained. On motion of Mr. FitzGerald it was voted that the amendments lie on the table and be printed in notice of the next meeting.

The Secretary read a communication from the Western Society of Engineers inviting this Society to send delegates to a meeting to be held in Chicago for the purpose of formulating plans for an International Engineering Congress. On motion of Mr. Stearns it was voted that the communication be referred to the Board of Government with full power to send a delegation if it sees fit.

The Secretary read a communication from Mr. E. L. Corthell, member of the Society, in relation to a movement, on the part of the Engineers' Club of St. Louis, to erect a monument to the late James B. Eads.

On motion it was voted;—That this Society indorse this movement of the Engineers' Club of St. Louis and desire to cooperate therein, and that the Secretary be authorized to receive contributions toward the monument fund.

On motion ot Mr. Brooks it was voted to extend the thanks of the Society to Col. S. M. Mansfield for his courtesy on the occasion of the visit to Fort Warren.

Mr. John R. Freeman read a paper entitled "Notes On English Mill Construction."

Mr. M. M. Tidd described the method of placing the piers at Prospect street bridge, Waltham, Mass.

[Adjourned] S. E. Tinkham,
Secretary.

ASSOCIATION OF ENGINEERING SOCIETIES.

ORGANIZED 1881.

Vol. IX. November, 1890. No. 11

SOME RECENT CONSTRUCTION OF RAILWAY BRIDGES.

BY JAMES RITCHIE, MEMBER OF CIVIL ENGINEERS CLUB OF CLEVELAND.

[Read August 12th, 1890.]

Since the first of the present year the writer has had many opportunities of comparing the recently constructed bridges of the different railroads of the country. Beginning with the Southern roads, a noticeable increase in the construction of iron bridges shows that the tendency toward the most permanent and substantial work has taken firm hold upon the management of southern roads. The Norfolk and Western R. R. has been building a large number of long and short span bridges both on its main line and its Western extension. The largest of these bridges is that across the Ohio River at Ceredo, W. Va., which is known as the "Ceredo" bridge. This bridge consists of one channel span of 518 feet, two spans of 298 feet, and a series of approach spans. The total weight of this structure complete will be 3,250 tons.

The main line bridges and the bridges of the Western extension are largely plate girders. All of the above are being built at Edgemoor.

The Louisville and Nashville R. R. have recently let contracts for about 2,000 tons of bridge work, distributed among the various bridge works of the East, and at the Louisville, Mt. Vernon and Shiffler bridge works west of the Alleghenies. The Nashville, Chattanooga & St. Louis R. R. has also placed several bridges and shop roofs at the Louisville Bridge Works, aggregating about 400 tons.

The East Tennessee, Virginia & Georgia R. R. have recently erected

the Ocmulgee river drawbridge of 212 feet span, the Florence drawbridge, several smaller bridges across the bayous and creeks of Alabama, and have placed with the Louisville Bridge Co. two 182 feet draw spans for Ocmulgee river.

The Georgia, Carolina & Northern Ry. have completed several 200 and 150 feet span bridges and have two others under construction, and the contracts let for two long bridges, one being over the Savannah river.

The Georgia Central Ry. and the Atlanta & West Point Ry. are having several bridges built also, and the Queen & Crescent Route are improving their line in the same manner.

In the West and Southwest the building of bridges is also being rapidly extended. The Union Bridge Co. is building ten spans for the Missouri, Kansas & Texas, the Ft. Smith bridge for the Missouri Pacific, and the Memphis bridge across the Mississippi river.

The Chicago Forge & Bolt Co. has built and just completed this year a large number of plate girder spans aggregating about 800 tons, for the St. Louis & San Francisco Ry.

The Phoenixville Bridge Works is building four bridges and Detroit has just completed three bridges for the St. Louis, Arkansas & Texas R. R.

In the East and North there is also considerable building and more under contract. The Maine Central has four bridges under way at Union Bridge Co. and one of three spans at Passaic. The New Jersey Steel and Iron Co. has several bridges for the N. Y. C. & H. R. Ry. and is also building the Burlington bridge across the Mississippi river for the C. B. & Q. R. R.

At Elmira Bridge Works there is being built for the N. Y. Central, a plate girder span of 115 feet in length. The girders, of which there are two, are straight on top and bottom and the web is 108″ × ⅜″ of iron. The plates are 72″ wide and consequently are placed with the fibre vertical. There are three angles in each flange, two being on the inside of the web and one on the outside. They are 6″ × 6″ × ¾″ in section, and the cover plates of flanges are 24″ × ⅝″. Also Elmira is building another bridge for N. Y. Central, which has one 95′-4½″ span and two 40 feet spans also of iron.

The Cuyahoga bridge of the Lake Shore Railway is a double track through drawbridge of 305′-10½″ span, built of wrought iron with steel eyebars by the Union Bridge Co. at their Buffalo shops. The total weight of the superstructure is 655,000 lbs. in round numbers and the weight of the turntable, which was built at the Athens shops, is 266,000 lbs.

The Ocmulgee river draw built by the Keystone Bridge Co., is 212 feet span and weighs complete including turntable, 259,792 lbs. This is a single track through span and the weights given both in this case and Cuyahoga draw do not include the track or ties, but only the actual bridge and floor system ready for the ties.

The following list of weights per running foot of the superstructure ready for the ties and rails but not including same, may be of interest to the members of this club. The weights are taken from actual bridges

which the writer has personally recorded in the books of the Pittsburgh Testing Laboratory.

Span.	LOADING. Engine Consolidation.	Train Load per foot.	Description of Truss. (All Single Track.)	Weight per foot excluding Ties and Rails.
212		4000 lbs.	Draw span, includ. drum.	1225 lbs.
205	2-104 ton.	3000 "	Through Pratt.	1600 "
200	2-85 "	3000 "	" "	1277 "
200	2-104 "	3000 "	" Camel Back.	1427 "
179′ 4½″	2-104 "	3000 "	" Pratt.	1400 "
179	2-104 ton.	3000 "	Through Draw Span.	1230 "
162	2-104 "	3000 "	" Pratt.	1210 "
160	2-112 "	4000 "	Deck "	1100 "
150	2-104 "	3000 "	Through Camel Back.	1165 "
148	2-112 "	4000 "	" Draw Span.	1122 "
145	2-104 "	3000 "	Deck Pratt.	904 "
148	2-112 "	4000 "	" "	1040 "
150	Train of 110 ton Engines.		Through Pratt.	1572 "
130	" "	" "	Deck Lattice.	810 "
120	" "	" "	Through Lattice.	1328 "
142	2-112 ton.	4000 lbs.	Deck Pratt.	1054 "
104	2-104 "	3000 "	" "	1010 "
102′6″	2-104 "	3000 "	Through Pratt.	1000 "
90	Train of 110 ton Engines.		Deck Lattice.	805 "
82	2-104 ton.	3000 lbs.	" "	781 "
80	2-112 "	4000 "	" "	700 "
76		4200 "	Through Plate.	1070 "
70	2-104 "	3000 "	" "	892 "
66	Train of 110 ton Engines.		Deck "	610 "
64′ 6″	2-104 ton.	3000 lbs.	" "	587 "
65		4000 "	" "	604 "
55	Train of 110 ton Engines.		Through "	740 "
53	" "	" "	Deck "	641 "
45	" "	" "	" "	626 "
30	" "	" "	" "	475 "

Many other instances could be cited to illustrate the relation between the weights and spans of different bridges.

Many other bridges than those previously mentioned have been built for the railroads in this section, notably for the Lake Shore, the Michigan Central, N. Y. Central, Pennsylvania, Toledo & Ohio Central, Toledo, Peoria & Western, and Wabash Ry., but time prevents further enumeration.

The writer wishes to comment upon a few of the details of bridge specifications and the material for bridges. Probably the specifications of Mr. Geo. S. Morison, engineer of the Memphis and Burlington bridges are the most complete and when thoroughly understood by the bridge companies will be the most satisfactory to them as well as to the other parties concerned. They specify everything, are arranged systematically

and are not susceptible of being evaded. When material is specified to be of such a quality and the line is distinctly drawn limiting the same, no deviation from these limits is possible under these specifications, and as soon as the absolute line or a similar one is used by all engineers, just so much easier will it be to obtain satisfactory work. The writer does not mean to imply that any condition should be made which is impossible to comply with, but that the condition should be such that manufacturers *can* comply with them, and that then no deviation from those conditions should be permitted. The general practice of bridge engineers is tending in this direction and with improvement in specifications and in their enforcement we shall find corresponding improvement in our engineering structures.

The N. Y. Central Ry. in specifying steel for bridges, now requires only *acid* open hearth steel, not permitting the use of Bessemer steel in any part of a bridge. The Memphis and Burlington bridges above referred to are built almost entirely of *basic* open hearth steel although acid open hearth steel will also be used in some parts of these bridges.

To many engineers the use of Basic open hearth steel is new and therefore they hesitate before specifying it. It has however shown, in the material for Memphis bridge, a uniformity in its chemical composition which speaks well for its being used largely in structural work. The percentages of phosphorus, sulphur and silicon have not generally varied over $^2/_{100}$ of one per cent. in the different heats. The carbon of course varies according to the grade of the steel, (there being three grades, soft, medium and high grade), between $^{14}/_{100}$ to $^3/_{10}$ of one per cent. but is very uniform in each grade. For steel plates it is said that this material has given good satisfaction.

It was at first intended to use only Bessemer steel in Memphis bridge but after making several tests and experiments the open hearth steel was adopted.

Many bridges are built under Cooper's specifications which are so familiar to all engineers as to need no explanation. The requirements of these specifications as to iron tension members seems to the writer to be too high in the relation of specimen to full size tests. The requirement of 52,000 lbs. ultimate on sections less than $4\frac{1}{2}$ square inches in specimen test and 50,000 lbs. ultimate in full size test seems to be too small an allowance. In making full size tests of iron eyebars to destruction, the writer has noticed that the bars fail (unless there is some flaw elsewhere) either near one head or the other, indicating that the material has possibly been injured in forging the head. It would perhaps cause the material to return to its original condition to anneal the eyebar in the same way that steel eyebars are annealed. The writer does not know of this having been done in any case but is of the opinion that a few experiments might be made with satisfactory results. Certainly no injury would be done and much good might be accomplished.

DISCUSSION.

MR. OSBORN:—I would suggest that if Mr. Ritchie has an opportunity he revise his paper by adding the loads for which the new bridges are designed besides the weights given: that data regarding weights in bridges is certainly very valuable, and the suggestion is made that the list be increased.

MR. BARBER:—A short time ago I was investigating the subject somewhat and found that there seemed to be considerable activity shown in the matter of railroad bridge construction throughout the country. The bridges that were built ten years ago were built for engines and trains of a certain weight, and from that time to the present I think the rolling stock has constantly been increasing in weight. The result has been that most all the old bridges—and even those built within a very few years past—have had to be rebuilt.

Mr. SWASEY:—I was somewhat interested in the statement made in Mr. Ritchie's paper in regard to the use of plate girders. He mentions one of 108 inches in depth. We see a great many girders of less depth than this, but do not hear of many of this depth.

MR. GIFFORD:—I recollect the bridge of the New York Central Railroad of which Mr. Ritchie speaks. In this bridge, which I think, is the longest plate girder that ever came under my notice, being of 115 feet span, the web is not made of plates 108 inches wide, but of a width of 72 inches, standing on end.

MR. REID:—[A visitor] Mr. Barber speaks of the tendency to increase the weight of cars:—I have noticed on some roads that where engines, ten or fifteen years ago, weighed but from 35 to 40 tons, now a weight of from 50 to 70 tons is the rule. The Lake Shore Road has cars carrying a load of 120,000 pounds of iron ore, this being exclusive of a car weight of 36,000 pounds, and on account of this great increase in weight the Company is changing a great many of its bridges.

MR. PORTER:—The use of steel seems to be on the increase as applied to railroad bridges; but, in my opinion, iron in a good many places is just as good—perhaps better—and much cheaper on account of ease in working it. My idea is that for bridge work hard steel is not very good, and in certain places in bridges I much prefer a soft steel. Last year the New York Central Road used comparatively soft steel in their bridge construction; but my opinion is that we can get nothing to excel iron where there is much abuse shown.

We all know that the Engineer of the Board of Commissioners of New York State, Mr. Stowel, is a strong advocate of riveted structures and the principal reason is, as I understand, that trains can run off the track on the structure and still it does not fall. This, of course, is a little exaggerated. A good many believe in another kind of structure. There are some cases where riveted work is preferable. The aim, I understand, is to put steel, in bridges, where it will not be likely to receive sudden blows. When the St. Charles bridge went down the conductor testified that they were going very slow. This had a cast iron upper chord, but we don't know that it was the cast iron which first failed.

MR. SEARLES:—The destruction of one of the spans of the St. Charles bridge was attributed to insufficient flooring, and the derailment of the car or the breaking of an axle drew the floor-beams together and left large spaces which resulted in the destruction of the entire truss, the cars falling into the spaces.

MR. PORTER:—A bridge floor should be not only notched down, but thoroughly bolted. Of course, there is a little play, but not much. Ties should be placed eight inches apart and, sometimes, less.

MR. PALMER:—Probably the chief difference between the plate girder and the truss in regard to endurance is that the plate is heavier, it being made entirely of riveted work. In American truss work, bars and pins are largely used, while, the English rivet their truss work very much more than we Americans do.

MR. BAKER:—Is there any tendency among Europeans to the use of the American pin connected truss? It seems to me that if the American bridges have stood the test of time and usage they would begin to come into use in the old country among the more prominent engineers.

MR. PORTER:—In many cases, for short spans, the road-men prefer to use a riveted structure; and many railroad companies specify them. There are certain local circumstances which may change any particular design; but the impression among railroad men is, I believe, that the riveted truss of 70 or 80 feet is much stiffer when the train passes over it than the pin connected truss.

MR. BIGGAR:—Would not the argument apply to longer spans? You limit it to 80 feet.

MR. PORTER:—Some do. Mr. Stowel, of New York, does not limit it, but runs it up to 200, if necessary.

MR. SWASEY:—Is it not a fact that greater repairs are required on a riveted than on a pin connected structure? The Sixth Avenue Elevated Railroad, of New York, I think is a pin connected structure and costs very little for repairs.

MR. BIGGAR:—From my own experience the repairs are considerably less in riveted work than the pin connection, on an average.

MR. RICE:—I think the common impression among engineers with whom I have talked is that plate-girder work has been the most expensive.

MR. SEARLES:—The European Engineers are remarkably conservative as to their designs. I do not know that the American pin system is being used in Europe; but it is in Australia. English railroad managers continue to use small cars. Perhaps it is only in America that we see large cars and prodigious loads. Possibly it is coming to a question as to the weight the rail can stand rather than the bridge, as whatever load comes on the bridge must come through the rail. There is a limit to the crushing qualities of steel if it is soft enough to be safe.

MEMBER:—The rivets are being removed from the Victoria bridge, at Montreal by the bushel every year. They are seen lying upon the ice beneath during the winter.

MR. BAKER:—The amount of strength of a rivet in a given structure

is one of the things we cannot find out, because the initial strain upon it after cooling is indeterminate.

MR. BIGGAR:—The statement just now in regard to the Victoria bridge I do not think is really the fact. It may be as described, of course, the Victoria bridge is constantly undergoing repairs, and, the rivets may have dropped on the ice. I think that so far as the Victoria bridge is concerned it is as good a bridge as any in America. It is a plate-girder bridge in which there is is a great weight of iron that might have been saved.

MR. SEARLES:—It is undoubtedly true that a great many rivets used to drop out in the winter time—that is, the heads have dropped off, from rivets in many of our riveted bridges.

There are a great many good qualities in rivet work. Probably one reason why rivet work is not more popular may be that the early structures built in the riveted fashion were more or less defective in workmanship, while at the present time, when as much of the work is done at the shop as possible upon riveted structures [the rivets being placed by hydraulic machinery, and the strain accurately adjusted to the size of the structure,] the work is more uniform in character. The probability is that modern rivet work will show better results. On the other hand we know that our pin connected structures are giving excellent service. The failure in either case may be attributed to defective workmanship at the time of construction or insufficient proportioning for modern loads.

IMPROVED RAILROAD TERMINAL FACILITIES IN PROVIDENCE, R. I.

BY SAMUEL L. MINOT, MEMBER BOSTON SOCIETY OF CIVIL ENGINEERS.

[Read May 21, 1890.]

The locations of the first railroads built into Providence were made to points on the Harbor on the southerly side of the city, skirting the easterly and southerly sides of the population as it then existed, and remote from the present centre.

The Boston & Providence Railroad was chartered in June, 1831 and in August of the same year Wm. Gibbs McNeil, Captain of U. S. Engineers, was engaged by the Board of Directors of the Corporation "for the purpose of determining generally, the circumstances under which a railroad could be constructed between the cities of Boston and Providence." Capt. McNeil's assistants were James Hayward, Lt. Isaac Trimble, E. T. Griswold, Lt. W. H. Swift, E. S. Chesborough, Lt. Thomas Stockton, Lt. Francis Vinton, J. C. Cadle and H. E. Rogers, some of whom were well known to the older members of this society.

In April, 1832, Capt. McNeil made a voluminous report, accompanied by maps and profiles and tables of estimates, appended to which was a very interesting and elaborate report prepared by H. E. Rogers, exhibiting the geological features of the country between Massachusetts and Narragansett Bays.

Very minute and thorough surveys were made of several routes, all terminating at India Point. This seems to have been selected from the first, by the projectors of the road, as the Southerly terminus, presumably for the purpose of making the most feasible connection by steamers with New York.

For a railroad line connecting the two termini by the most direct route the location, as finally adopted, was made with remarkable skill and intelligence. In the light of present conditions it would seem that a mistake was made in the line selected. Had the Directors realized the importance of developing local business, or had they in any way considered what they learned later, that it was necessary to enter Providence from the north, the route through Dedham, Walpole, Wrentham, North Attleborough and Pawtucket would have been chosen. This location would have been in the vicinity of the stage line over the old Boston and Providence Turnpike, now known as Washington street through all the towns from Boston to Pawtucket.

The road as located under the Massachusetts charter ended near the east end of India Bridge, the state line at that time being the easterly shore of Seekonk river.

In May, 1834, the Rhode Island Legislature chartered the Boston and Providence Railroad and Transportation Co., authorized to connect with the railroad then being constructed from Boston, to build a bridge across Seekonk river, passing into the State of Rhode Island to tide water in the city of Providence, and to build wharves, docks, basins, warehouses, depots, etc.

The construction of the road was begun in 1832 and completed in three years, being opened from Boston to Providence in August, 1835.

The original charters in both states, provided that any person might enter upon the road with his own cars and engines, by paying such tolls as might be agreed upon and established by the Directors, and complying, with such rules and regulations as they, from time to time, might prescribe. Availing themselves of this provision, Tristam Burgess and others of Providence, in 1836, obtained a charter for the Seekonk Branch Railroad, proposing to build about 2,000 feet of road at Seekonk, now East Providence, a separate station in Boston, and to use the intermediate part of the Boston and Providence R. R. with their own engines and cars. The annoyance caused by the operation of these parties led to the purchase of the property of the branch road by the Boston and Providence, in 1840, and the passage of an act by the Massachusetts Legislature, forbidding one railroad corporation to enter, with its engines, upon the road of another company, except by their consent.

The Boston and Providence road was a financial success from the start. Notwithstanding the lack of local traffic, the business between the two

principal cities of New England, and that from the Taunton and New Bedford road acting as a feeder, being sufficient to pay good semi-annual dividends, from December, 1835, with three exceptions, in 1855 and 1856.

Soon after the road from Boston to Providence was projected, parties in Rhode Island, Connecticut and New York secured charters from the two first named states, for the New York, Providence and Boston Railroad to run from Providence to Stonington, there to connect with steamers for New York. This road was built under the direction of Wm. Gibbs McNeil and opened to Providence in 1838. Among the assistant engineers on the location and construction were our honored fellow member, Mr. James B. Francis, Mr. A. S. Matthews who continued in the service of the road until his death a few years since, and Mr. John A. Burnham, afterwards a wealthy manufacturer. The location is a first-class one from Stonington to a point now known as Auburn, about five miles from the city. From this point it took nearly a northeasterly direction, terminating on Providence River at a point opposite Fox Point. This terminus was the natural one in view of the desired connection by ferry with the Boston and Providence road at India Point. the road being designed as part of a through line from Boston to New York. The projectors in those days had to grope, as did those of the Boston road. There was small opportunity for development at the Providence terminus of either road.

The Stonington road was not, at first, a financial success. The traffic. although there was at that time practically no competition, was very light, and the road seemed almost on the verge of bankruptcy. This was partly owing to the exorbitant rates charged by the steamboat lines at the New York end, as was shown in an able report on the condition and prospects of the road, made by Capt. McNeil in 1840. In this report he recommended the purchase of steamers by the company, in order to make an independent line from Providence to New York, and also suggested the building of a bridge across Providence river, to avoid the detention to through travel of about half an hour caused by the ferry.

In the course of a few years the prospects of the road began to brighten and when in 1846 the Boston and Providence secured an entrance into Providence in connection with the Providence and Worcester Railroad, the Directors saw that an opportunity was presented for the company to improve its fortunes. A charter was secured for an extension from Auburn, and in 1848 the road terminating at the Cove lands, was completed. From the time of this new departure, the success of this road has been uninterrupted.

In 1845, the Boston and Providence road was threatened with a loss of business by the building of an opposition road from Attleboro to Pawtucket, to connect at the latter place with the Providence and Worcester Railroad, then being constructed from Providence to Worcester. This was rather a startling condition of things for managers so conservative as were those of the old road. But they proved equal to the occasion, and in March, 1846, a charter was obtained for a branch road which was immediately built from a point south of Dodgeville, on the main line, to the state line in the direction of Central Falls. In the same charter authority

was granted to make a connection with the Providence and Worcester railroad, in Rhode Island, and to purchase depot accommodations in the city of Providence. Under this authority a joint ownership with the Worcester road was secured, of the location from the junction at Central Falls to the city and of portions of the terminal station and grounds, and a separate ownership of other parts.

After these roads had completed their plans for entering the city the first important question was the erection of a depot. The Providence and Worcester being the first on the ground took the initiative, and in 1846 petitioned the city government for the right to erect a suitable depot. It was a long time before permission could be obtained. Several committees considered the matter, and finally the right was granted and the construction begun. The structure, which is the one now standing, is of comely *external* appearance. It was first built in two sections, the westerly part being owned by the Boston and Providence and the easterly by the Providence and Worcester. The part now used as a restaurant, being joint property of the two roads, was built later, the whole completed in 1848.

The building of the extensions of the Boston and Stonington roads was an effectual remedy for the defects of the first locations, and together with the construction of the Providence and Worcester, proved of immense benefit, not only to themselves but to the city. The city grew rapidly, and there was a corresponding increase in the travel and freight traffic over these three roads.

The Hartford, Providence and Fishkill Railroad was chartered by the Rhode Island General Assembly in 1852 and built soon afterwards. The Providence and Springfield, chartered in 1857 was built to Pascoag in 1873. These two roads were built with a view to giving greater facilities for western connections, and each had its terminus on the Cove lands, the first named with passenger accommodations at the Union Station.

In 1873 Mayor Doyle appointed a commission, which a year or two later proposed a radical change in the railroad system of Providence by abandoning the joint location of the Boston and Worcester roads, from a point north of Corliss' Engine Works, and building a new road west of Smith's Hill, terminating in a butt-end station west of the Cove basin about one quarter of a mile from the present station. This scheme fell through, as the railroad companies saw no good reason for giving up the valuable franchise held by them, and the city did not seem inclined to take their property for other public use, the only purpose for which it would legally be taken.

During all those years there was a constantly increasing demand for improved terminal facilities on the part of the business men of the city. The railroad companies had little chance for expansion, except upon city land.

In August, 1881, the Boston and Providence and Providence and Worcester railroad companies petitioned the city government for the grant or purchase of certain filled and unfilled lands belonging to the city. This petition led to action on the part of the city council, which resulted in the appointment by Mayor Hayward of what was commonly known as the

Goddard commission, consisting of Wm. Goddard, S. S. Sprague, Robert Knight, H. E. Wellman and Charles Warren Lippitt, all well known business men of the city.

Under instructions of the city council, the Commissioners were "to appraise the lands belonging to the city known as the 'cove' and 'cove lands,' to fix the price thereof, and to negotiate the sale or exchange of the whole or any part of said lands with the several railroad companies desiring to purchase the same; also to report to the city council, on or before April 1, 1882, a plan or plans for the increase of railroad terminal facilities for both freight and passengers, and such new streets as may be necessary in consequence of the adoption of their proposed plan or plans, with authority to employ a secretary and such assistance of engineers or otherwise as may be deemed necessary to the proper performance of their duty."

The Commissioners entered upon their duties in December, 1881, with the avowed purpose of meeting the representatives of the different railroad companies in a spirit of friendliness, and with their united help to work out a plan which would be beneficial both to them and to the city.

During their investigations they gave several public hearings which were largely attended, the public interest in the matter being very great. They endeavored to acquaint themselves with the general sentiment of the citizens of Providence respecting the location of passenger and freight stations, the questions of filling up the Cove and of grade crossings, and they also invited the opinion of eminent scientific authorities with respect to the influence upon the public health and the effect upon the harbor of Providence of filling the Cove, and of its occupation for railroad purposes.

These investigations satisfied the Commissioners that the opposition to filling the Cove was very limited, that the opinion in favor of abolishing grade crossings was unanimous, and that the solid sense of the people of the city favored the retention substantially of the present site of the passenger station instead of its abandonment for one remote or inaccessible.

The Commissioners made their report April 17, 1882. The plan proposed provided for filling the Cove basin; reserving walled channels for the waters of the Woonasquatucket and Moshassuck rivers, the widening of Exchange Place about 125 feet and the location of the passenger station on its northerly line, substantially in the rear of the present station, and for overhead crossings, carrying the highways over the railroad.

Upon the presentation of this report, I was employed by the Boston and Providence railroad to make an estimate of the cost of the Commissioners' plan, to that company, and to report upon its feasibility. Mr. John W. Ellis was employed for a similar purpose by the Providence and Worcester company. The property of these two companies was held so much in common that we made our investigations jointly. Upon making our reports, our companies decided that the cost of the scheme was too great. We found the feature of the overhead crossing proved to be very expensive. Besides we were not satisfied with this method of approaching the freight yards and houses of the two roads, which were to be placed on the westerly side of the main track, upon the present area of the Cove.

During our investigations of this plan, it occurred to us that the elevated system was the proper one, keeping in view the main purpose the Commissioners wished to accomplish. The suggestion of this to the Commissioners was cordially received by them, and the idea was soon developed into what was known as the "Goddard Plan". Later I acted as Consulting Engineer for the New York, Providence and Boston road in developing the scheme for the entrance of the roads from the west, into the Union Station. The engineers of the railroad companies were in frequent consultation with the City Engineer of Providence, and with the Commissioners, from the summer of 1882 to the time of the presentation of their second report to the city council, December 27, 1883. Mr. Charles Warren Lippitt dissented from the majority and made a minority report. While he agreed to the engineering features of the plan, he differed from the majority as to the method of building the station, favoring its being done by a terminal station company instead of the railroad companies in possession of the present property.

The majority report and plan were immediately accepted by the city council, and within two months by the Boston and Providence. the New York, Providence and Boston, and the Providence and Worcester railroad companies.

The plan contemplated an elevated station, with an approach from Smith street on a grade of about 23 feet per mile. and from the west on a grade of 18½ feet per mile. The station was to front on Exchange Place, which was to be widened to the extension of the north line of Washington street, the centre of the building being one hundred feet west of the centre of the present station. The Cove was to be filled in, reserving an ample channel for the Woonasquatucket river, the Moshassuck being carried under Canal street. Highways were to be built across the Cove, connecting with Smith's Hill, two to be carried under the elevated structure, one at each end of the train house, which was to be 1,000 feet long. The highways were to be on substantially level grades.

Some modifications of the plan, desired by the engineers, would probably have saved it from certain prejudices which were afterwards developed.

The Commissioners were authorized by the City Council to negotiate with the railroad companies for the sale or exchange of lands, but there was lacking legislative authority for *taking* land. Upon application to the General Assembly, a joint Special Committee was appointed to consider and report upon a bill to enable the City of Providence and the railroad companies to carry out the plan adopted by the city, and accepted by the railroads, for the increase of railway terminal facilities. Hearings were given running through nearly five weeks of March and April, 1884.

Much opposition to the Commissioners' plan was developed, led by the late George H. Corliss and the late Judge Charles S. Bradley. The main point and aim of the opposition, as presented to the committee, was that the railroad companies ought to be compelled to move from their present situation to the Cove lands west of Gaspee street. They seemed to forget that the railroads, as much as the city, were parties whose assent was

necessary to make any plan for increased terminal facilities effective. The cry of "railroad monopoly" was raised, also "Chinese Walls," and the bridges under the elevated road were designated as "rat holes," although their capacity for the admission of light was larger than that of the bridges under the elevated railroad and station at Philadelphia, and were of about the same length. Much eloquence was expended by Judge Bradley and others upon the beauties of the Cove Basin and Promenade.

Mr. Corliss brought forward a plan similar to that of the Commission of 1873. This seemed to be the favorite scheme of the opponents of the Commissioners' plan, especially of those owning land west of Smith's Hill, and in the Woonasquatucket Valley west of the Cove lands, also of the esthetic gentlemen interested in preserving the Cove as a Public Park. With the "plain people" of Ward 10, "railroad monopoly" was sufficient ground for opposition.

Many of the solid business men of Providence, merchants and manufacturers, appeared before the Committee in advocacy of the Commissioners' plan. They recognized the fact that the railroads took a natural course when they located into Providence through the Moshassuck Valley from the north, and the Woonasquatucket Valley from the west, and also that the vested interests of the railroads in the lands they occupied under condemnation, by act of the General Assembly, were as sacred as those of any private individual.

The Committee reported, and the Legislature passed a bill granting the authority asked for. It authorized the taking of land covering an extensive area between Smith's Hill and the works of the Nicholson File Company, without committal to any definite plan.

Acting under this authority, the Commissioners, (who were the four first named of the original Commission), continued their labors for carry-into effect the plan, until November, 1886, when the Providence and Worcester Company finally rejected the plan. Rather than spend any considerable sum for improvements in Providence, the managers of that road seemed to prefer a prospective ten per cent. lease of their property, based on a million increase of capital stock, soon after applied for to the Massachusetts Legislature, on the pretext, in part, of the necessity for making these very improvements. In the correspondence of the President of the company with Col. Goddard, it was contended that it was impracticable to build the structures proposed in the Cove, on account of the very difficult foundations, an opinion contrary to that of his own engineer. This correspondence is "interesting reading" to-day, in view of actual tests that have been made, and of what is now going on in the Cove under city contracts.

As soon as the Worcester road withdrew its acceptance of the plan, the Goddard Commission resigned, after devoting a great deal of their time, for nearly five years, ably, conscientiously and gratuitously to the service of the city.

"Terminal facilities" continued to be a subject of agitation before Committees of the City Council and of the General Assembly, during the winter, spring and summer of 1887, but with no result till September of

the same year, when the City Council passed a resolution, requesting the Mayor "to appoint a Commission, to consist of three impartial and disinterested persons residing without the State, who shall be practical and skilled railroad engineers, and who shall, as soon as possible, visit the City of Providence, and after making a thorough examination of the present terminal facilities of the railroads entering the Cove lands within the said city, the topography of the lands contiguous and adjacent thereto, together with the requirements for an adequate accommodation of the public, report to the City Council, for their approval, the best plan in their judgment for enlarged terminal facilities for said railroads, including therein locations and general plans for a new passenger station, freight houses, together with approaches and track connections therewith."

Acting under the authority given by this resolution, Mayor Robbins appointed as a Commission of Expert Engineers, Joseph M. Wilson of Philadelphia, D. J. Whittemore of Milwaukee, and Alfred P. Boller of New York.

The plan the Commission reported to the City Council, April 13th, 1888, provided for a new location around the foot of Smith's Hill, a passenger station to be located near the old State's Prison, the filling in of the Cove Basin, preferably for a public park, and the elimination of grade crossings, the crossings to be carried overhead. The passenger station was to comprise a train shed 560 feet in length, with five tracks under cover, flanked on the south by the station building proper, and facing the proposed park. Two of the tracks were for through passenger business, and three for local trains. There were to be two tracks outside the train shed for through freight.

The freight yards and houses of the roads entering from the north, were to be between Canal street and the through tracks, and of those entering from the west, between West Exchange street and the through tracks, the northerly yards extending a short distance into the filled Cove Basin.

Such were the main features of the Experts' plan, which was accepted by the City Council with alacrity. Their chief argument for the plan was the saving in distance of 1,730 feet, and in curvature of 79½ degrees, and the consequent saving in the cost of operation for through trains of about $10,000 per annum.

No estimate of cost to the city or railroads was made by the Experts. They state in the first part of their report that "any plan presented by them must be a reasonable one; that is, one that the railroads could carry out, and one that would not too violently disturb a long established railroad centre with its surrounding growth of business interests." It was evidently the opinion of a large majority of the business men of Providence that the change the Experts proposed, would seriously disturb existing values of property. At least, this would seem to have been their better second thought, though at first many of them appeared willing to accept this plan, thinking they could get no other.

The location of the freight yards, while quite convenient for those doing business south and east of the railroad, was very inconvenient for

the manufacturing establishments in the Woonasquatucket Valley west of the old State's Prison. The method of connecting the territory with the rest of the city, by means of the crossings over the railroads, was not one to promote its future development.

The passenger station was badly located for doing the growing suburban business of the different roads.

A serious objection to the station was the limited accommodations provided for the train service, being about equal to the requirements of the present time, but wholly inadequate to the future growth and needs of the city. Besides, it was impossible to enlarge the station in length or width, leaving the streets as adopted by the city council.

The plan was not acceptable to any of the railroad companies.

In the summer of 1888, the New York, Providence and Boston road, had come into possession of the Providence and Worcester by lease, and the Old Colony road, of the Boston and Providence. The Managers of the two roads informed the committee on terminal facilities of the city council that they wished to have plans prepared with a view to reconciling the conflicting interests of the city and railroads.

In a communication from the General Managers, dated July 19th, 1888, Mr. E. P. Dawley, Chief Engineer of the New York, Providence and Boston road, and myself, were instructed to examine two studies of proposed terminal facilities at Providence, which had been placed in their hands, and to report upon the same, estimating the cost etc. One was for an elevated road and station, the other a surface road, the highways to be carried over it. Either station was to be located in the rear of the present station. Each combined covered through tracks with two butt-end stations for local trains. It was at once seen that the large area required for a station of this character would make it very expensive, with no benefits corresponding to the outlay. We were at liberty to modify these plans, or devise any other which we thought best suited to the situation, and were recommended to study the plans of the Rochester, Buffalo and Philadelphia elevated systems.

The General Managers expressed a view which agreed with the preconceived opinion of the engineers, as follows: "The advantages of an elevated track are manifest. All trains are out of the way of the public; they can be run with absolute safety to and from the station; all our own property can be fully enclosed and protected. The platform of the station can be kept private and free from all passengers until the arrivai or departure of trains."

Matters were now simplified by the combination of interests of the Stonington and Worcester roads.

Alter months of careful study we decided upon the plan which has now been accepted by all parties interested. This plan, which has so successfully defied adverse criticism, so much so that it has no outspoken opponent, was designed to embrace all the good points of the plans that had gone before, and omit all the bad ones.

It was designed to suit the City, the Railroads, and all reasonable opponents of previous schemes.

Of course grade crossings were to be eliminated, but even if the tracks were elevated there must not be an elevated station.

There were to be no "Chinese walls," no "rat holes" through embankments, no steps up into the depot or steps down into the train shed.

The streets crossing the railroads were to be neither elevated or depressed. There were to be no columns in the streets and no lack of head room for teams.

To draw a plan, and overcome all objections, was the task attempted. The arrangement of freight yards to suit the needs of the different companies was not the least difficult problem.

It can be said that this plan has been designed in all its features by railroad men and railroad engineers who were reasonably familiar with the needs of the railroads in Providence and the notions of prominent citizens. How well they have succeeded remains to be proved.

A description of how the plan was constructed will perhaps most clearly describe it.

Each of its main features was the result of much study, and final combination and conclusions were only arrived at after great labor in drawing, estimating cost, comparing plans, making trial positions for the buildings and approaches, etc. The first point to consider was: Shall the station remain near its present site or be removed to the rear of the Cove as had been proposed by eminent engineers.

As public opinion had been fully expressed on this point and was in accordance with the views of the management of the railroads, it was finally settled in favor of keeping it as near as was possible to the present station and accomplish all else that was desirable.

The next question was: Shall the streets go over the tracks or the tracks over the streets.

This question settled itself in our minds in favor of placing the tracks over the streets, for the following reasons:

First, the present station being in the valley with down grades approaching it of from 15 to 40 feet per mile and lying only a few feet above tide water, it was impossible to much further depress the tracks.

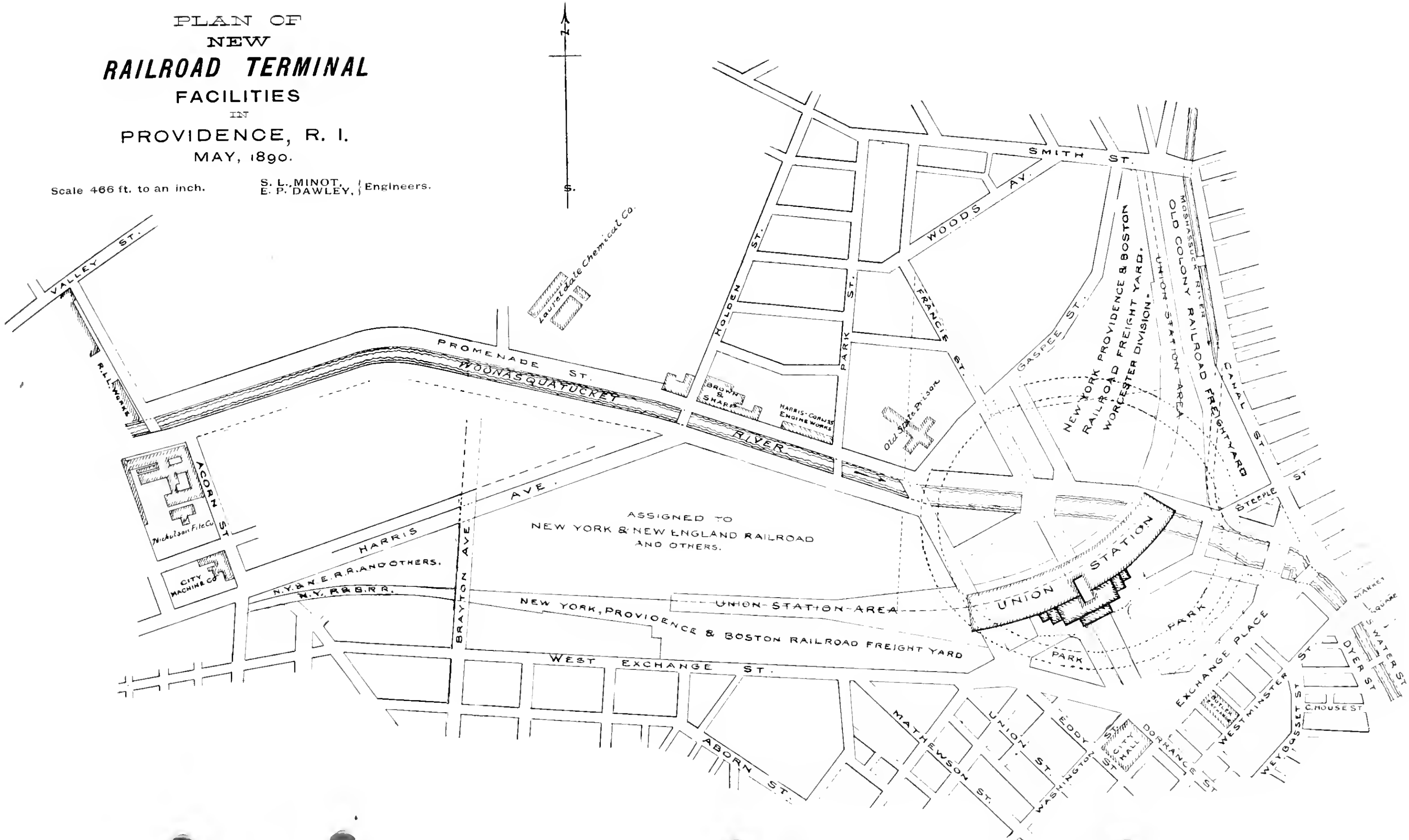
Second, by keeping the new station near the present one the streets could not be carried over without long and winding inclines.

Third, it seemed very undesirable to forever shut out the large Woonasquatucket valley from all communication with the centre of the city except by these overhead bridges, and also very unfair to the railroads which would of necessity have their freight yards located so that the bulk of their team freight should be hauled over these bridges.

Fourth, and finally, what was more natural, than to reverse the track grades and let the tracks approach the station on ascending grades, a condition most desirable in the operation of a large station.

The prime feature contended for by the City (next to the removal of grade crossings), in any plan, has been direct and ample street communication between the central portion of the city and Smith's Hill, so called.

To meet this demand a street 80 feet wide was drawn from the center of the City, or the square in front of the City Hall, to the best street


PLAN OF
NEW
RAILROAD TERMINAL
FACILITIES
IN
PROVIDENCE, R. I.
MAY, 1890.
Scale 466 ft. to an inch.
S. L. MINOT,
E. P. DAWLEY, Engineers.
N.
S.
VALLEY ST.
R. L. Works
Laurel Dale Chemical Co.
PROMENADE ST.
WOONASQUATUCKET RIVER
HOLDEN ST.
PARK ST.
FRANCIS ST.
WOODS AV.
SMITH ST.
BROWN & SHARPE
HARRIS-CORLISS ENGINE WORKS
Old State Prison
GASPEE ST.
NEW YORK PROVIDENCE & BOSTON RAILROAD FREIGHT YARD.
WORCESTER DIVISION.
UNION STATION AREA
OLD COLONY RAILROAD FREIGHT YARD
MOSHASSUCK RIVER
CANAL ST.
STEEPLE ST.
ACORN ST.
Nicholson File Co.
CITY MACHINE CO.
HARRIS AVE.
BRAYTON AVE.
ASSIGNED TO NEW YORK & NEW ENGLAND RAILROAD AND OTHERS.
N.Y. & N.E. R.R. AND OTHERS.
N.Y. P. & B. R.R.
UNION STATION AREA
NEW YORK, PROVIDENCE & BOSTON RAILROAD FREIGHT YARD
UNION STATION
PARK
PARK
WEST EXCHANGE ST.
EXCHANGE PLACE
MARKET SQUARE
S. WATER ST.
DYER ST.
C. HOUSE ST.
WESTMINSTER ST.
WEYBOSSET ST.
BUTLER EXCHANGE
DORRANCE ST.
CITY HALL
EDDY ST.
WASHINGTON ST.
UNION ST.
MATHEWSON ST.
ABORN ST.

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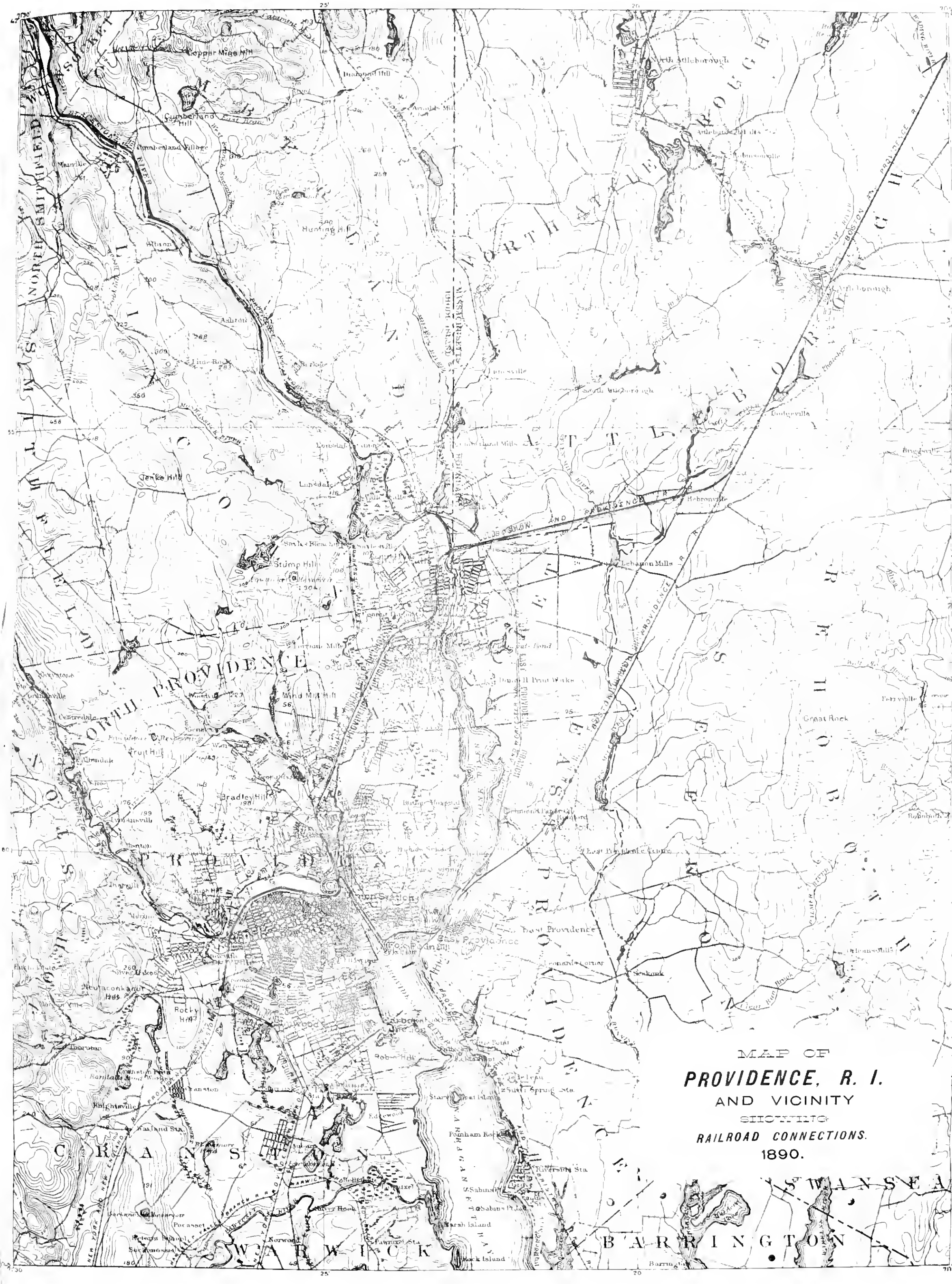

MAP OF
PROVIDENCE, R. I.
AND VICINITY
SHOWING
RAILROAD CONNECTIONS.
1890.
NORTH PROVIDENCE
PROVIDENCE
CRANSTON
WARWICK
BARRINGTON
SWANSEA
EAST PROVIDENCE
SEEKONK
REHOBOTH
ATTLEBOROUGH
NORTH ATTLEBOROUGH
CUMBERLAND
NORTH SMITHFIELD
LINCOLN
SMITHFIELD
JOHNSTON
Copper Mine Hill
Diamond Hill
Cumberland Hill
Cumberland Village
Manville
Hunting Hill
Albion
Ashton
Lime Rock
Lonsdale
Jenks Hill
Stump Hill
Wind Mill Hill
Bradley Hill
Rocky Hill
Neutaconkanut
Fruit Hill
Centredale
Greystone
Knightsville
Auburn
Pawtuxet
Edgewood
Pomham Rocks
Riverside Sta.
Sabin Pt.
Marsh Island
Rock Island
Norwood
East Providence
Seekonk
Lebanon Mills
Hebronville
Dodgeville
Attleborough
North Attleborough
South Attleborough
Great Rock
Perryville
Rehoboth
Orleans Mills
Union Station
Fox Point
Starve Goat Island
NARRAGANSETT BAY
BOSTON AND PROVIDENCE R.R.
PROVIDENCE AND WORCESTER R.R.
NEW YORK AND NEW ENGLAND R.R.
MASSACHUSETTS
RHODE ISLAND

ascending the Hill. The grade of this street was fixed on the present surface and the surface of the filling to be made in the Cove, it being from 5 to 10 feet above mean high tide.

This being the most direct route possible between the centre of the City and the Hill it could not be criticised.

To make it still more desirable it was determined that no freight yards should front thereon.

Then came the question of how to get the tracks over this new street and not make a dark and undesirable crossing.

Only the through tracks, four for passenger and two for freight were allowed to go over, and as there were to be various other stub tracks for local trains it was necessary to stop them on either side of this street. A bridge was therefore conceived which would carry the through tracks as is shown on the plan, and after various studies of how to arrange the depot building, so that there should be but one general waiting room and set of ticket offices (a feature insisted upon), it was decided to bridge this street at one more place, separate and apart from the track crossing, and place the waiting room, in part right over the street, thus securing for it plenty of light and ventilation from above and easy access from either side of this particular street, below. This gave us as the plan shows two bridges over this main street, each of reasonable width, with 14 feet clear height, and a stretch of open daylight 118 feet long between.

Two other streets were projected, each 70 feet wide, under the track, each to serve a purpose and to take the freight business away from the main thoroughfare.

No other plan has so well provided for street accomodation across the tracks. Next came the question of how to arrange the front of the station so that it could not be called an elevated station. This was done by placing it back just far enough to permit of sloping the approaches to a reasonable carriage grade on either side of the main street to the hill. There are provided up this slope four carriage approaches, two with grades of four feet per one hundred, one of three feet per hundred and one of two feet per hundred.

There are also left on this gentle slope about seven acres of ground to be made into an attractive public garden.

There are no steps up into the depot from the point where a carriage will leave its occupants.

The track-approaches to the station are on embankments and have a rise of about 30 feet per mile or a total rise of about 8 feet above the point where the new grade leaves the present track. There are no walls designed to sustain the embankments.

The depot building is to be of ample size to meet all requirements.

The train shed will be 200 feet wide in the clear and 1,000 feet long on the rear line.

The baggage and express rooms are so located that the business may be conveniently done without being in the way.

Large and desirable rooms have been provided for under the train shed, fronting on the main street through the depot, for the use of a public

cab company, so that passengers may descend from the waiting room and enter these carriages without going out of doors.

The bridge floors over the streets have received a good deal of study and it is expected with floors of moderate thickness to span the 70 and 80 foot streets with columns only on the curb lines. This is done by means of cantilever brackets. All of the bridge floors will be of the Pencoyd corrugated shapes, trough section, and be perfectly water-tight.

The bridge over the river will have the same floor and be a deck span sufficient to carry the train shed in addition to the tracks.

The track systems have all been so designed that the movement of all switches and signals will be controlled by an interlocking system and worked from a tower at either end of the station and are so arranged that any train on any main track approaching the station can be run in on to any track in the station and the same can be done in the opposite direction.

The saving in distance for through trains over the present alignment, is 840 feet, while the saving by the expert's plan was 1,730 feet. The saving in curvature is 79½ degrees, the same as by the expert's plan. The maximum degree of curves is $6^2/_3$ and by the expert's plan, 10.

The through freight tracks, two in number, will pass the station in the rear of the train shed.

It may not be apparent without attention being called to it that the curve through the station is a compound curve, compounded on the centre line of the main street through the depot. This was done in preference to a simple curve throughout. to bring all the construction of the depot building square to the street at this point and make the whole work and plan symmetrical about this one axis.

It is expected that the furnishings and architecture of the depot will be equal to the best of such structures in the United States.

On reflection it seems that the whole scheme is simple enough, but a large amount of study has been given to it in every detail, from the position of the pile foundation in its solid gravel bed under the station up to and including such things as investigations into comparative width of platforms between tracks and tracks per number of trains, in the various stations throughout the country, and we hope that the fifteen years of study, with the production of many plans has served to finally develope the best thing for the situation.

The freight yards have been carefully sized to meet the needs of the different companies.

The freight yard of the Old Colony railroad will cover the land between Smith street and the projected street under the east end of the train shed, bounded on the east by Canal street and on the west by the elevated railroad. The freight yard of the Worcester Division of the New York, Providence and Boston road will be reached by this projected street and cover the land between the elevated tracks and the new location of Gaspee street. The freight yard of the New York, Providence and Boston railroad will cover about 430,000 square feet of land between West Exchange street and the elevated railroad, lying west of the projected street

under the west end of the train shed. The freight yards of the New York and New England and Providence and Springfield roads will be reached by this projected street and will cover so much of the land north of the elevated railroad as they may require.

By an act of the General Assembly of Rhode Island the Old Colony Railroad Company and the New York, Providence and Boston Railroad Company are authorized to construct a passenger station and the appraches thereto, in accordance with this plan. In the construction of the station these corporations are required to "provide convenient and suitable accommadations therein and upon and over said approaches thereto for all other railroads now or hereafter entering or terminating in the city of Providence."

These descriptions relate to the arrangement of passenger and freight facilities at or near the Cove, or in the central location. "Terminal facilities" for Providence should include a system of circuit, or belt roads, connecting all the suburbs with the central station. One of the most important of these connections is that of the Providence, Warren and Bristol railroad, by means of an elevated road through South Water street, a charter for which has been granted by the General Assembly to the Old Colony Railroad Company. This will supply a long felt want of direct connection of the centre of the city with the east shore of Narragansett Bay and with the cities of Fall River and Newport. The location of the passenger station is a favorable one and the elevation of the tracks in it has been fixed with special reference to a connection with the elevated road.

The New York, Providence and Boston Railroad Company has been granted the right to build a bridge across Providence river at Fox Point. By building this bridge, with proper connections from its easterly end to the east shore of Seekonk river and northerly with the elevated railroad through South Water street, important circuit lines can be formed, connecting the central station with Olneyville, Elmwood, Auburn, Roger Williams Park, Harbor Junction, Fox Point, East Providence, Rumford, East Junction, Hebronville, Pleasant View, Valley Falls, Central Falls, Pawtucket and Woodlawn.

The cities of Providence and Pawtucket and their suburbs are rapidly growing and now contain a population estimated at 220,000.

The completion of these lines will furnish unsurpassed facilities for running rapid transit trains, and will result in a greatly accelerated increase of population and business, with corresponding benefits to the railroad companies owning and operating the roads.

Important as is this briefly outlined system of belt roads for the passenger business of Providence, it is still more important in connection with the freight traffic, as it connects all the railroads entering Providence with the deep water front on both sides of the river, and allows through freight and freight interchanges to be taken around the city without going through the central passenger locality.

By means of the belt line and the extension of the tracks of the New York, Providence and Boston road from Allen's avenue to Crawford street

bridge, as proposed by the Goddard Commission in their report of 1882, a connection can be made with all the wharves in the city. With this work accomplished, the inconvenient and dangerous tracks in Market square and Dorrance street can be removed.

With the whole scheme carried into effect, Providence will be provided with a railroad system sufficient for its rapid growth and development for fifty years.

THE ASYLUM STREET CROSSING AT HARTFORD, CONN.

By L. B. Bidwell, Member, Boston Society of Civil Engineers.

[Read May 21, 1890.]

In the year 1842 an extension of the New Haven and Hartford Railroad was made to Springfield, Mass. At that time the Hartford station was on the southeast side of what is now Bushnell Park, at the foot of Mulbury street; and the New York and Hartford road approached the station from the south and swung across Park river, near its present shops of that road, and across what is now the Park on what was called the long curve, of about 6,500 feet (run on chords of 200 feet, with a radius of 5.000 feet, each full station representing 200 feet and so numbered.) Leaving the station at Mulbury street the Springfield extension passed to the west and north, over the Park, River, and crossed Asylum street at grade near the present depot site thence north across low swampy ground a distance of 1,700 feet to and across Walnut street at grade, then about 1,000 feet still farther north passed by an arch under North Main street and Albany Avenue near their junction

In 1849 the Hartford, Providence and Fishkill Railroad was built parallel to the Springfield extension to the north of West Main street and Albany Avenue, and the station at Mulbury street was abandoned and a Union station built just north of Asylum street, over which, the changed tracks of the New Haven, Hartford and Springfield, and the Hartford Providence and Fishkill roads passed at grade. At this time there were no buildings for quite a distance east of the crossing and few west of it. Both roads were poor, yet they together built what was then considered a very fine station about 357 feet long, and 93 feet wide, with a single track for each road through the station, and with waiting rooms on each side. The architectural effect was good, certainly preferable to many more modern structures for the same purpose; and with the single tracks, it was not inconvenient. I have no record of the placing of a flagman, or gates, on Asylum street, but have the impression that it was about

1860 that a gate was placed on each the New Haven, Hartford and Springfield and the Hartford, Providence and Fishkill sides. It was made of one heavy pole, which swung across the track and highway. The only accident I have heard of there was caused by a frightened horse running down Asylum street from the west, striking the gate which was across the highway, swinging and breaking it; the broken piece striking a child on the the side-walk. In later years there was very heavy travel on this street as the city grew to the west; and as trains were increased, and more or less switching was necessarily done across the street, the delay to teams was such that a separation of grades was certainly desirable.

Much talk was had, a good deal of printers ink wasted, and some plans made, but nothing definite was done, until in 1884 the Legislature passed an act to separate the grades and established a commission, composed of the three Railroad Commissioners, the Mayor of Hartford, and a representative for the two railroads, to decide on a plan, and fixed the amount to be paid by the city at not over one-half of the expenditure, the balance to be borne by the two railroad companies equally. It was expressly stated that the city should bear no part of the expense of a new station building.

In the year 1867 Broad Street about 1,600 feet south from Asylum street was carried over the tracks by an iron bridge. Walnut street rose as it left the railroads both to the east and west. Asylum street rose to the west with a grade of about 6 in 100; and to the east there was a slight descent, to Ford street about 500 feet, then a gradually increasing rise further east. It will be seen, that having Albany Avenue 2,700 feet north and Broad street 1,600 feet south already over, and the railroads level from Albany Avenue to the station, and rising but about 8 feet from the station to Broad street, and Walnut street rising each way from the track, and Asylum street rising heavily to the west, also with a rising grade not very far to the east,—that the physical indications were all one way, that the street should be carried over the railroads. In June 1884 the Commissioners called on the railroad companies for plans for separating the grades, and we presented two, for carrying the street over. There was, however, on Union Place just east of the station and between Union Place and High street, valuable property in business buildings, and an expensive church, and as a low approach would in this case be required to the station, the main part of Asylum street if carried over, would have had to be swung to the south reaching on to, and taking a small part of the Park grounds and of the Julius Catline estate, also valuable land west of the crossing. This was one of the earliest considered plans and commended itself to the railroad companies, but the city representative opposed any detour of the street, and the matter was delayed.

In December 1884 another request was made for the railroad companies to prepare plans for a straight-away over crossings of the street 55 feet wide, and the New York and New England Railroad Company presented complete plans leaving the tracks as they were, except lowering them 2 feet at the street, and giving 18 feet clear head room. A careful estimate of the cost was $140,414.

The New York and New Haven Road at this time presented no plan. The first decision of the Commision was I think in December 1884 and was that the street should be carried over the tracks on its present site; the approach to the station was to be by stairs on the east at Union Place and by an incline on the west at Spruce street. This banked up somewhat against the church property the height increasing as the tracks were approached and it buried the lower stories of the business blocks, and doubts were expressed as to abutters being able to get anything for the damage. This of course met with strong opposition; the city representative was strenuous in his objection to any detour of the elevated street. May 16, 1885 a plan was presented by the New York and New Haven Railroad Company for elevating the tracks, and placing the station between them, on which my estimate for construction was $241,858, not including the station. This included some supports for station platform etc., on which the Commission thought the city should pay no part, and they required new plans omitting this, and reducing the width to be occupied for bridges over Asylum street to 95 feet, and made the clear height 13 feet. For convenience this required two stations. My estimate of cost of construction and land exclusive of station was $185,140.

On the 22d. of October, 1885, the commission rescinded their first order and adopted the west side plan. An engineer employed by the city estimated the cost of this plan $117, 683. I claimed $145,387 in necessary retaining walls and land making a total of $263.070. The New York and New Haven Company's estimate on this plan was about $287,-000. This however did not suit all the citizens a few of whom began to think of the dollars; for it required no special engineering talent to understand that tunneling through this clay hill, and the Catline estate would be very expensive This plan beyond all others was objectionable to the New York and New England Railroad Company, as it practically destroyed their yard, and as they were in the hands of a Receiver and under the shelter of the court, not much could be done without their consent, therefore this plan did not progress.

Finally the elevated plan was adopted as a compromise, and plans and estimates were made for elevating about 100 feet in width with retaining walls and earth filling for a small arch for foot passengers at Church street produced, three arches for communication between the new station, which was to be on Union Place, and the west, and for stairways to the middle platform. This plan, which was estimated at $234,643, not including the new station building, was adopted by the Commission early in 1887. Later, and before any work was done between Church and Asylum Streets, the railroad companies proposed to put in between these streets an iron trestle founded on stone piers, and agreed to bear themselves any increased expense over the cost of the retaining walls, earth filling and arches; and the Commission accepted this change. The estimated cost of the walls, earth filling and arches was about $123,-000.

By agreement of the parties and the order of the Commission the two

railroad companies were to do all the work except the lowering of Asylum street and raising of Walnut street.

A contract was made with John Beattie for the granite rubble retaining walls at $5.20 per cubic yard and for the granite cut face and rubble back abutment walls at $8 per cubic yard.

Temporary stations were erected on Union Place and Spruce streets, leaving a cramped room for the trains, but a fair opportunity for doing the work between. On the New York and New England side between Church and Walnut streets, the ground was originally low and sloped to the west, and had been filled with yellow clay, and the wall was on a curve of 1,146 feet radius convex to the west. On account of this and of the poor bond which could be had with the stock, I made the section quite thick for the height, the base at 16 feet below the coping, being 8 feet and at 5 feet below 5½ feet. There was also a 30-inch sewer running lengthwise for two or three hundred feet on the site of the wall, and this was removed, and this space (and wherever the clay was soft, about 2 feet extra that was removed) was refilled with sand and gravel thoroughly wet when filled in and levelled; on this the wall seems to stand well. Some of the disadvantages of this elevated plan are: that all trains have to be lifted 8 feet higher than the fixed level at Broad street; that Walnut street has been raised 6 feet which will in the future, largely increase the cost of carrying it over; that all passengers have to climb from 16 to 18 feet, for although there is a passenger elevator people do not find or readily use such an appliance at railroad stations. All baggage has also to be elevated about 13½ feet, consuming much time and necessitating a large force of men. The exposure to cold winds is greater than on the lower level.

The great advantage of the elevated tracks is that it is possible, though at some inconvenience and loss of time, to compel people to go from the waiting rooms to the trains without crossing the tracks. The arrangements are as follows: From Asylum street north, to Church street (about 700 feet) is an open iron trestle work resting on stone piers with spans generally of about 25 feet, the tracks being about 16 feet above the level. There are two side platforms of 18 feet, and a middle platform of 24 feet. Between the east and middle platforms is a double track for the New York, New Haven, & Hartford Railroad, and between the west and middle platforms, a double track for the New York and New England Railroad, both of these tracks are 12 feet apart on centres. The station is about 475 feet long, the centre being 63×179 feet, the north wing 40×160 feet, and the south wing 40×136 feet, and fronting on Union Place. The station is in two stories, the lower one is about 6 feet above the general level of the surrounding ground, and is approached by a slight slope on the ground, and by 8 steps. In the general lower waiting rooms on the Union Place side is a middle door-way with a ticket office on one side for the New York and New England, and the other side for the New York, New Haven and Hartford. On the side which adjoins the elevated trestle work there are two stair-ways of about 16 feet wide, each divided by a hand rail and leading parallel with the tracks from each end of the building to a landing about 13½ feet above the waiting room

floor, and about eight inches above the level of the tracks; and with large doors leading to the track platform to the north bound track of the New York and New Haven Railroad. Under these stair-ways are three doors, one side door leading to and from the middle platform for the south bound track on the New York and New Haven Railroad, one to and from the same middle platform for the New York and New England east bound, and the middle one to a passage from which one can go to the New York and New England west bound. There is a picket fence between the north and south bound track of the New York and New Haven, and one between the east and west bound tracks of the New York and New England. There are turn-stiles at the elevated platform level at a stair-way from Asylum street to the New York and New Haven side and at the middle platform, so that passengers can pass down from the trains to Asylum street but cannot return except through the station. The stair-way to Asylum street from the side platform on the New England side and the one at the middle from the same side platform, have as yet no turn-stiles.

The arrangement of stairs at Church street is the same as at Asylum street. When a train approaches on either or both roads, it is announced in the lower waiting room and the passengers are directed to the door which leads to it.

With the exception of those who are to take the north bound track on the New Haven Road, all passengers who wish to be comfortable in cold weather, must wait below until the train comes in, and then climb about 13½ feet of stairs: for although there is a passenger elevator on the side of the station next to the tracks, people either do not understand about it, or will not wait. Even if one wished to use it, it would be useless except for the one north bound track. In fact if you have elevated tracks, people must and will climb these stairs.

There is an upper ticket office on the New York and New England side platform, which sold a good many tickets for both east and west, before the fence was placed between the New York and New England tracks; now it is practically useless except for west bound passengers. All baggage must be elevated.

The plan of the building and tracks are best for leaving the whole track level of the trestle planked over even with the rails, and free ingress and egress from all the stair-ways and no fences between the tracks, and with the present method of using, it would be better if the stair-ways inside of the waiting room were removed, and four separate side doors led to passages to each of the four tracks. There is no avoiding inconvenience, and loss of time to get, and keep people in a rut, and where they will be reasonably safe, all have to be directed and taken care of like children. With some faults and inconvenience, it is the only station that I know of in this country where trains on four tracks pass by the station, while it is so arranged that passengers can go to and from any train without crossing at grade any track. This cannot be readily done in any other way than by having the waiting rooms either below or above the track level, for certainly it is enough to compel passengers to climb or go down only one flight of stairs, from a waiting room to take a train, and other things being

equal I should prefer to have the waiting rooms above, and approach them if need be by an easy incline, and go down stairs from the waiting room to take the train, as there are many people who can go down stairs, and that in a reasonable time, who cannot well go up them. and even with four tracks, the people from two of them might be discharged generally from below from both outside tracks, and cross none at grade. From the two inner ones of course, they must go upstairs, or cross one track at grade. In these days,' more than ever before, time is money, and all are in a hurry, it is very irritating for these people to have to be at the station early, or get left, and it is also hard to make them go up and down stairs especially the weak and infirm, and yet as I said before all must be taken care of like so many children, and there is no safety for a railroad company except in so arranging the stations as to make delay. The fence between the New York and New Haven tracks was put up a very considerable time before the one between the New England tracks, and a sliding gate was placed opposite the upper landing doors, but even with this in the hands of a good man it was difficult to prevent people from rushing through, and getting into danger, so when the New England fence was put in, no gate was left in either except opposite the baggage room.

DISCUSSION.

MR. A. W. LOCKE:—I think this society is to be congratulated on having two such able, well prepared papers as have been read by Mr. Minot and Mr. Bidwell to-night.

With reference to Mr. Bidwell's paper and the Asylum St. crossing at Hartford, it seems to me it would have been more reasonable in that case if the streets had been carried over the railroads instead of raising the two railroads to carry them over the streets.

The land is high on the north side of the tracks and favorable to the plan of raising the streets.

I have never heard what the reasons were for the adoption of the plan of raising the railroad. But it seems to me like a plan for putting the trouble and inconvenience necessary to ensure safety all upon the railroads and their patrons.

I believe passengers should be fully protected and cared for when going on board the cars and when leaving them. There is too much hap-hazard about it at present at most stations; too much of a disposition to require the passenger to look out for himself in the presence of moving trains.

They are nearer right in some foreign countries where passengers are literally taken care of like children. And they are not allowed to cross a track at all; much less are they allowed to cross tracks where express trains are liable to come.

The elevated railroads of New York come as near to getting their passengers in and out of their cars without exposing them to danger as any road I know of. The Metropolitan Railroad of London (underground) has also an excellent system. The passengers descend by one stairway to a north bound train or by another stairway to a south bound train. No one is allowed to step foot on the tracks.

I notice that Mr. Bidwell states that the tracks at Hartford are 12 feet apart on centres or only 7 feet between nearest rails. That is not distance enough; 10 feet would be much better. But only one road in the country that I know of has so much and that is the Northern Pacific, which, so far as I observed in riding over it has 10 feet of space between tracks in front of all stations. I understood that this was arranged by Mr. Doane, member of this society, when chief engineer of that road.

The Massachusetts Railroad Commissioners' report of a year ago contained a very complete discussion of the proper methods of building stations. I took a great deal of satisfaction in reading it.

Since the general subject of terminal facilities seems to be up for discussion it would be well to bear in mind the financial side of the case. The railroads are only agents for the traveling public. Supposed to be doing the work for cost and a fair interest on the investment.

And the traveling public by rail and highway can have such large and desirable improvements as those at Hartford and Providence just as soon as it is willing to pay for them. It is desirable to have safe and commodious stations and that highway grade crossings should be abolished but it must be remembered that the patrons of the railroad and the travellers on the highway have got to pay the bills.

MR C. F. ALLEN:—One point that strikes me rather forcibly in connection with the scheme of the railroads at Providence is that the public is in many ways so well accommodated by it. Singularly enough the scheme of the expert commission, appointed in the interests of the public, located the station building at some distance from the heart of the city for the supposed benefit of the railroads, by making the through line shorter; while in the scheme of the railroads a very noticeable feature is the great advantage to the public, in streets practically level, as well as very direct. Practically the only advantage to the railroads in the railroad scheme is that the public is better accommodated by carrying the station building nearer the heart of the city; so that the railroad gets no advantage from its own scheme except what results from superior accommodation to the public; while the public is benefitted by practically every change made from the plans of the expert commission appointed in its interests. It seems to me that a special merit of the belt line lies in shortening the distance for through freight business, so that, taken altogether, the present scheme accomplishes everything reached by the expert commission and much more besides.

MR. G. T. SAMPSON:—Without discussing details of the plan I think that the general layout at Providence will accommodate the public and the railroads as well as it could be brought about; and I can also say that it seems to me much superior to the plan of the experts.

Mr. Locke in speaking about the financial side and the payments for such improvements, says that the expense falls upon the travelling public; and that the patrons of the railroads must pay the bills. This is certainly the state of affairs which ought to exist, for it is only just to assume that every legitimate business properly handled ought to not only support itself but in addition afford a fair rate of interest on the capital invested, but I fear it is not commonly looked upon in that light and the railroad companies are considered by the public and the legislators as strong enough to assume any burden. The passenger or shipper of freight seldom or never pays any increased rates after such large expenditures. Indeed there is a constant demand for reductions in rates regardless of such matters and the railroad commissioners in some states arbitrarily order such reductions.

As a rule the railroads are obliged to issue additional bonds or stocks to pay for such improvements and luckily, in most cases, an increased business seems to provide sufficient revenue to meet the additional interest charges.

The public, through its city governments or legislative bodies not only have a very great (I might say controlling) influence in saying what plans shall be adopted, but they also control by legislation the rate of fare to be paid by passengers and shippers of freight, about the sole source of railroad income.

From a strictly theoretical standpoint it is questionable whether expenditures for such purposes ought to be capitalized, and whether or not the rates should not be high enough to afford a surplus, over and above a fair interest charge, sufficient to provide for such emergencies.

If railroad business should remain at a fixed volume, without increase, it is difficult to see how such increased charges could be met, and under the existing state of affairs it is difficult to see how the travelling public pays the bills.

RAILROAD INTERLOCKING SIGNAL DEVICES.

By Isham Randolph, Member, Western Society of Engineers.

[Read October 1, 1890.]

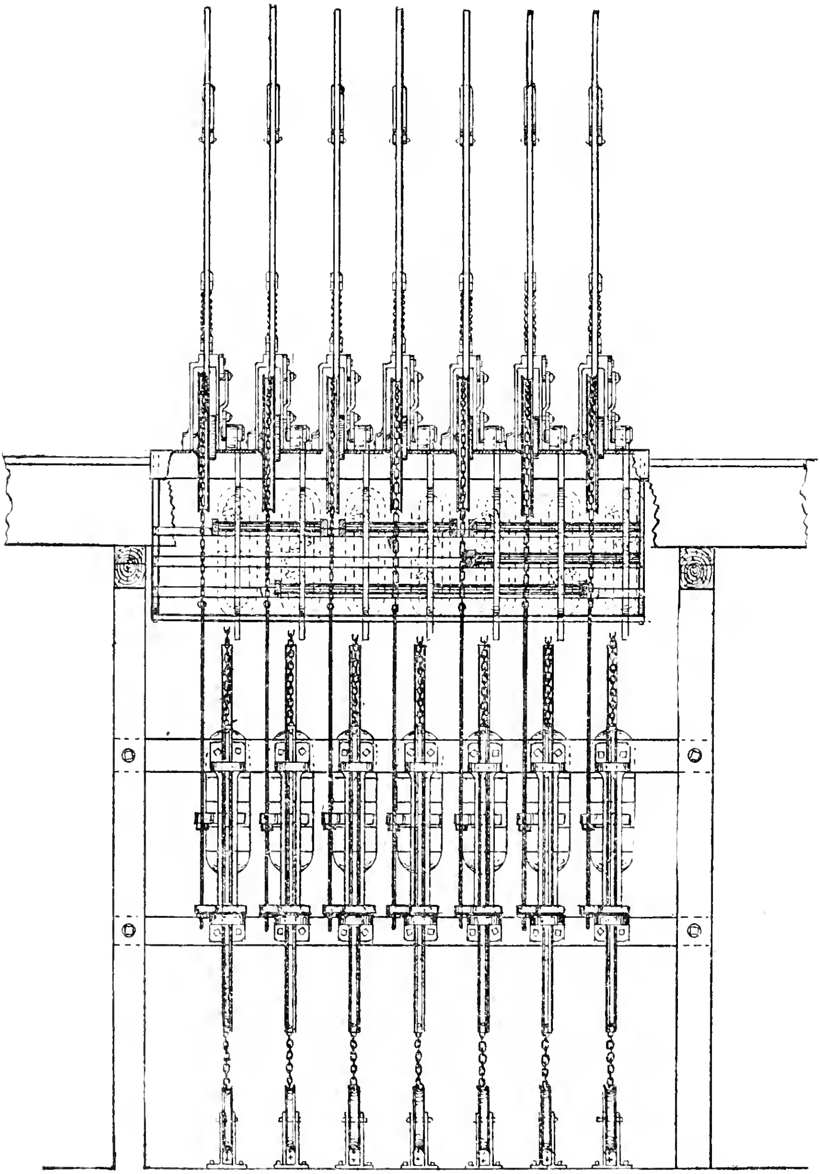
I feel as though I owed an apology for responding to the request made to me by the Chair for a paper on the subject of such great and growing importance as R. R. signaling and interlocking. An apology made fitting by reason of the manner in which I shall treat the subject assigned me. My remarks will not be broadly catholic but, so to speak, narrowly sectarian; and worse even than that, it will, I fear, seem to you that I have seized upon this opportunity to blow my own trumpet and advertise my

own wares. My only excuse lies in the fact that I know a great deal more about what I have accomplished in this direction than I do about what others laboring in the same field have brought to pass. Besides which the accomplishments of other inventors whose inventions have passed into the hands of the great companies now operating in this field, have been so fully advertised and so widely discussed that a discussion of their merits here would be almost like thrashing over old straw. What I have succeeded in doing after years of effort, in the face of discouragements so great and failures so frequent, that I have often rued the day which first turned my thoughts into this channel, is known to very few, and I can but feel that you will be interested in seeing what I have accomplished and in listening to a short history of my struggles against heavy odds. In May. 1880, I reported for duty as chief engineer of the Chicago & Western Indiana R. R. A few months later in an interview with the Vice-President of the company, Mr. Andrew Crawford, I was asked by him what I knew about R. R. signals and interlocking devices. I told him very frankly that I did not know a "blessed thing" about them. He said that the subject was a very important one and in view of the future requirements of our road he wished that I would take it up and make a study of it, ascertain what there was then available and also see what I could devise that would be likely to do good service. From that conversation dates my ambition to do something original in the direction then outlined. Many have been the nights of unrest born of this ambition and frequent the mortifications and disappointments which have grown out of it. I investigated the appliances to be seen in the vicinity of Chicago, which at that day were very crude and unsatisfactory, and found but little to commend and much that I thought I could improve upon. About that time the Union Switch and Signal Co. put in a pneumatic electrical plant at the crossing of the Rock Island and Stock Yards tracks. It was costly, complicated, and not fully satisfactory, in fact did not seem to be just what was wanted. There existed a prejudice through the west against derailing appliances as being in the nature of a cure worse than the disease, and I entertained this prejudice in common with those about me and made up my mind that what was wanted was a visible signal so placed that it would extend nearly across the track at the height of a headlight, reasoning that the breaking of an engineer's headlight would be prima facia evidence of his having disregarded the signal and proof sufficient to fasten the blame upon him, and insure such discipline for the offense as would inspire a wholesome reverence for the signal. Working on this line I evolved the machine of which I exhibit a drawing, rescued from the debris of many moves. It is an adaptation of an old-fashioned farm gate, built on the principle of the parallel ruler which many of you may have seen. A red light was suspended to the bar which stood normally across the track; a white light was concealed beneath the hood on top of the frame. When the operator gave safety by reversing the position of the bar, the red light passed behind a shield, the hood lifted and the white or safety light was displayed. This was considered by myself and friends a wonderful achievement and the company put several of them into service and they did just what was ex-

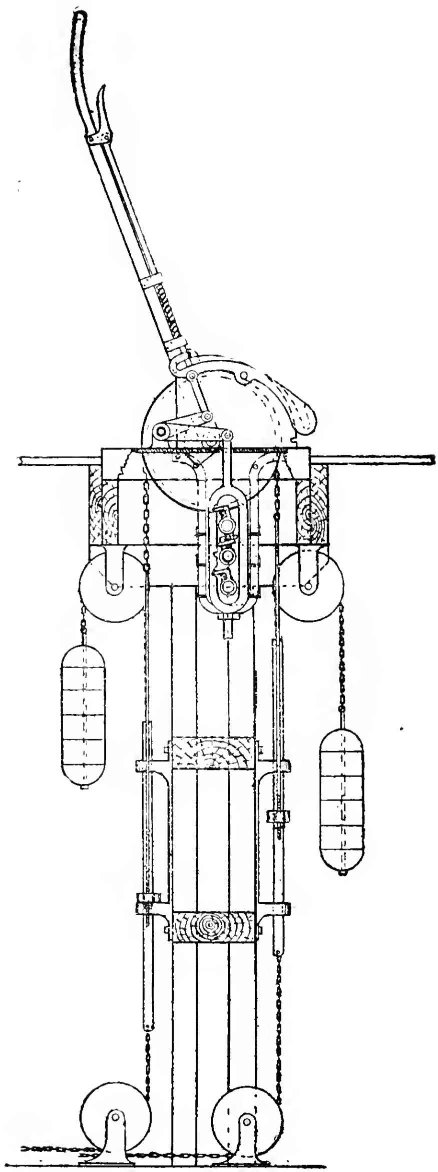
pected of them and broke every headlight that attempted to pass without the countersign. You can imagine my mortification and indignation when I took Mr. Jackson, Superintendent of the Union Switch and Signal Co., out to see what I had wrought, carrylng with me the hope that he would fall in love with and offer to buy my invention, when he laughed derisively without even doing it in his sleeve. I vowed a vow to myself that if I lived I would get up a system that even he should not sneeze at. This first taste of ridicule did not cure me of my belief that I was on the right line and my next move was to change the form of my signal bar to that shown in the tracing which I now exhibit. The frame was retained almost as before, but for the parallel ruler principle was substituted a bifurcated bar as shown hinged to a boom, the other end of which was made fast to the frame. To the frame was attached two flanged wheels bearing upon the top edges of the bifurcated bar. On the end of the bar toward the track was a hood which hung just over the center of the track. This was fitted with red lenses through which the light shone from a white lantern pivotally suspended within. The change from danger to safety was brought about by a pull on a cable or chain attached to the boom which was drawn up to a nearly upright position, bringing with it the bar which was tipped to the vertical by the two wheels riding upon its upper edge as before described. The pivoted white light swung out from behind the red lenses and the track was clear. Several of these went into immediate use, notably four at the Auburn crossing of the Chicago & Western Indiana and Rock Island Railroads, where they did yeoman service for seven or eight years, and were only removed last Spring to make way for one of the latest improved plants of the Union Switch & Signal Company. For the protection of outlying switches I got up a system of semaphores and levers interlocked with the switches, illustrated by the tracing which I now exhibit. I think that I read a paper on this system several years ago which was published in the *Journal* and fully illustrated. This system has been in use upon the C. R. I. & P., the C. M. & St. P., the I. C. and the C. & W. I. Railroads and has unquestioned merit. But it would require more of your valuable time than I have the assurance to consume were I to take up in detail all of my inventions, good, bad and indifferent, so I will omit those which have gone to my general stock of experience without adding to my store of useful inventions and come at once to recent and I believe permanently good work. I was converted long ago to modern ideas of what the railroads ought to have and to use for the protection of life, limb, and property, and have been working on those lines with a view, first, to producing thoroughly reliable devices for the work to be done, and secondly, to arrive at the greatest simplicity of construction consistent with the first aim, and thirdly, to produce a system at so low a cost as to place it within the reach of our poorer roads, as protection is coming to be recognized as a necessity, a duty which the common carrier owes to the public. For the protection of railroad crossings the following named devices are commonly used: Interlocking machine, (usually placed in a tower to facilitate the observations of the operator),

mechanism for operating switches, called switch machines; detector bars which are placed alongside the rail to prevent any switch or derailing point being thrown under a passing train or engine; home signals whose indications are positive either for danger or safety, and distant signals, which are cautionary. These explanations are for those among us, if any there be, who are as ignorant of this subject as I was when I first began to look into it. I have here two models showing my earlier interlocking machine, many of which are now in use and my latest preliminary locking machine, which is publicly shown for the first time this evening. The interlocking in the original machine is accomplished by the movement of a locking bar or plate which is actuated for locking by the circular cams attached to the levers acting against friction rollers made fast to the locking plate; the unlocking is accomplished by gravity, the heavy weight attached by a chain to the locking plate acting over the pulley at one end returns the plate to its normal position of all unlocked ready for action. The sequence of movement between primary or switch levers and secondary or signal levers is accomplished by the yoke locks (see model) and the interlocking between signal levers governing direction of movement upon a single track is effected by a rocker shaft working in eccentric cams on the journals of the signal levers. Of these machines I have several now in constant use. It is a good machine, but unless the workmanship is very exact, in the language of the switchmen you can beat the machine. Many persons urged upon me the importance of bringing out a preliminary interlocking machine which means one in which the interlocking is done with the grip before the lever is moved, and after two years of thought on the subject I have evolved the one shown in the half-sized model now before you. This machine is susceptible of an endless variety of combinations and no tricky switchman can beat it The power is transmitted from the grip through the latch rod and the system of levers and cranks to the locking bars and tumblers beneath the bed plate, the bed plate standing flush with the floor. In the normal condition of the levers all primary (switch) levers are free and all secondary (signal) levers are locked. Upon gripping a switch lever and lifting the latch, the latches of all conflicting switch levers are instantly locked, the lever is then reversed and as the latch sinks into the reverse notch it releases the levers of signals protecting the switch then in use. Grasping one of the freed signal levers locks the switch lever latch in its backward or safety position, where it is held until the signal lever is again returned to danger and the latch dropped. I think that this machine is less complex than any other yet devised for the purpose and in efficiency equal to any of them. We will now follow from the interlocker outward, taking each device in turn. Thus far I have constructed only wire machines, although there is no reason why I should confine myself to such connections, as my system is well adapted to pipe connections. For my compensator I have adopted the principle of the Jene lifting jack. The connections are made fast to one end of a rod which passes through guide brackets and an annular clutch to the other (upper) end a chain is made fast, which passing over a pulley is weighted; when idle the clutch rests upon the lower bracket and

the rod plays freely through it as the connections expand or contract, the weight drawing in the expansion or being lifted by contraction. As soon as the lever is applied the clutch to which it is connected by a lifting rod takes hold and does the work assigned to it. This device has proven very efficient. I show a model of one style of switch machine and drawings of a later device with which I am superseding it. The device of which we have the model, is a machine of great power and efficiency but it is costly and has too many wearing parts. The machine shown in the drawings has the merit of simplicity, strength and economy. As you see, it consists essentially of a bed plate to which is pivoted an equalizer, a couple of toggle joints with slotted holes are attached at each end of the equalizer, and their other ends are brought together at the center of a bar working in guides, one pin passes through both toggles and bar; the bed plate is made fast to the switch ties so that the movement of this bar may be parallel with the track; the switch rod or pitman is made fast at one end to the equalizer and to the throw rail, and at the other end, one pin passing through pitman equalizer and toggle. On top of the bar to the center of which the toggles are fixed, is a smaller bar bolted on through slots with a play of about 1¼ inch. The connections are made to this bar. With the switch in either position the thrust is transmitted through the toggles and is at right angles to the movement bar forming an absolute lock. Underneath the switch machine is the frame of a plunger lock through which the connection is made to the signals; unless the switch is right for it the safety signal cannot be given and when it is given the switch is locked by it and cannot be changed until the signal is again set to danger. Passing a few feet beyond the switch machine we come to my improved cam movement, the object of which is to distribute the labor of operating the several parts. This device enables us with one continuous stroke of the lever to operate the detector bar first, then relieved of that lift, the labor of the switch comes next and the weight of the detector bar dropping into position is transmitted through the cam movement and aids the throw of the switch. It consists of a bed plate with guides in which a bar works parallel with the track and said bar having a spike or finger at its center pointing away from the track, and on each side of this finger recesses for receiving the rollers on the ends of a double crank. This crank is made fast to the bed plate, as seen in the actual machine now shown you, and the connection to the detector bar is made from it. In one extreme position a roller of the double crank fits snugly into the recess in the bar on its side of the finger, while the corresponding roller on the other side is entirely free. When the power is applied to the bar to change the position of the mechanism, the crank is moved by the movement of the bar until the roller which was in the recess rolls out of it, at which time both rollers are in contact with the face of the bar which is then relieved of all strain upon it except the slight friction from the rollers. The bar moves forward until the finger strikes the reverse roller, tipping it into the reverse recess and completing the movement of the cranks. This machine reduces the labor on levers operating switches and detector bars amazingly. I had an operator say to me a few weeks since,



FRONT VIEW OF RANDOLPH'S PRELIMINARY INTERLOCKING MACHINE, COMPENSATOR WEIGHTS AND PULLEYS REMOVED TO ADMIT OF SHOWING INTERLOCKING TUMBLERS, DOGS AND LINKS.



END VIEW OF RANDOLPH'S PRELIMINARY INTERLOCKING MACHINE.

Mr. Randolph, I don't like hard work but can't you do something to this machine to make it work a little harder, it throws so easy that I feel as if it could not be doing its work. We have now reached the detector bar, and I submit a drawing of my own on which patent has just been allowed. It consists of a bar about 40 feet long, working against the outside of the rail and kept in place by brackets which guide it. The brackets are attached by a clamp or clip which is susceptible of adjustment to varying widths of head and base; attached to the bar at regular or suitable intervals are jaws in which are fixed rollers which move upon the rib cast in the bracket inclined both ways from its center. The pin which holds the roller in the jaw passes through a bar running over the whole space occupied by the brackets. The force for moving the detector bar is applied through this second bar. The motion of the detector bar is only vertical while the second bar moves parallel with the rail, 2½ inches. The first 1¼ brings the detector bar to its highest position, some ¾ inch above the rail, and the second 1¼ drops it again to its normal position. This bar is easily attached without boring the rail and has all the elements of a first class device for its peculiar uses. We now come to the signals. They are of the usual semaphore type with a few peculiarities. Both home and distant semaphores are operated by one lever and the regular sequence of movement, home signal first to safety then distant, distant signal first to danger then home, is effected by the motion plates on the mast, which are so difficult to picture in words that I will have to rely mainly upon the drawings. The only difference between the mechanism of the home and distant signals is in the different positions of the notch. Besides these signals, I have patented a pot or dwarf signal which, like the other signals, cannot be painted in words by so poor a language artist as I am. This invention was the offspring of necessity; I had certain conditions to meet and I could only meet them with this machine; and I got into the fix I was before such an idea ever dawned upon me. At Cayuga, Ind., I have two of these dwarf semaphores, two detector bars and two (2) derailers, all operated by one lever and the sequence of movement is perfect. Gentlemen, my subject is far from being exhausted, but I fear your patience has reached its limit, so I will close with a word of warning to such of my young comrades as I may dare to advise. Avoid invention as you would the wine when it is red, and Solomon's temperance lecture rings in your ears. You who have homes and living relatives, think of them and forbear to bring reproach upon an honored name by willfully lapsing into the insanity of invention. If you love your ease and enjoy nights of calm repose eschew the evil thing, for nothing short of a conscience harrowed by a remembered murder can so effectually murder sleep. If you have a small bank account and want to see it grow, turn aside from the patent lawyer and the pattern maker; go not thou in their ways lest thou give thy wages for that which profiteth not. But if the fever is in your brain and you must create a new device, let it be a safety pin or pants stretcher or some little thing like that which, ministering to the follies of mankind, will beguile them of their small change and make your pockets plethoric, and when the plethora sets in stop there and never try again.

REQUIREMENTS TO BE COMPLIED WITH IN THE CONSTRUCTION OF INTERLOCKING, SIGNALING AND DERAILING DEVICES AT GRADE CROSSINGS OF INTERSECTING LINES OF RAILROAD IN THE STATE OF ILLINOIS.

Office of the RAILROAD AND WAREHOUSE COMMISSION,
Springfield. Illinois.

The plan and construction of Interlocking, Signaling and Derailing Devices to be used at grade crossings of intersecting lines of Railroads in Illinois, must be arranged to conform to the following

GENERAL RULES:

1. The normal position of all signals must indicate danger,—derail points open—and the interlocking so arranged that it will be impossible for operator to give conflicting signals.

2. On level tracks, when practicable, the derail points in high-speed tracks must be placed three hundred (300) feet from fouling point at intersection of crossing tracks.

3. On descending grades, the derail points on high-speed tracks, when practicable, must be so located as to give the measure of safety equal to three hundred (300) feet on level track.

4. The minimum distance for derail points on high-speed tracks is three hundred (300) feet from fouling point at crossing, and no less distance from crossing will be approved, on account of descending grade toward crossing.

5. On switching, storage and slow-speed tracks, the position of derail points may be located to best accommodate the traffic, and provide the same measure of safety indicated in foregoing rules.

6. On single track railroads, derail points, when practicable, should be on inside of curve, and when double track is used, the derail points should be in outside rail of both tracks.

7. Home signal posts must be fifty (50) feet beyond point of derail. Distance between home and distance signal must not be less than twelve hundred (1,200) feet. Signal post should be placed on engineman's side of track it governs.

8. In case but one derail is furnished in double track crossing, where the current of traffic is in one direction, detector bars must be provided on opposite side of crossing from derails. and worked on same lever as derail, or interlocked with it, so that opposing signal cannot be given until crossing is cleared. In case trains back over crossing, after having passed over it, or if current of traffic is changed, then and in that case back-up derail, must be provided.

9. Guard rails must be laid on inside of rail opposite derail, and commence at least six (6) feet toward home signal from point of derail, extending from thence toward crossing, parallel with and nine inches distant from traffic rail, total length two hundred (200) feet, unless otherwise ordered.

10. In case there are cross-overs, turn-outs, or other connecting tracks involved in the general system, the movements of cars and trains upon which present an element of danger, which danger will be enhanced by the passage of trains on main tracks over crossings without stopping, and consequently at higher speed than would be the case without the permit sought, then, and in all such cases, whether such enhanced danger be of collision between different cars or trains of the same road, or between cars or trains of different roads, it will be necessary, in addition to the protection of the main crossing, to provide by the proper devices and appliances against any such increased collateral dangers in the same complete manner that is required in the case of the main crossing.

11. Application for inspection of interlocking plant must be accompanied by a plain diagram, showing location of crossing and position of all main tracks, sidings, switches, turn-outs, etc. The several tracks must be indicated by letters or figures, and reference made to each, explaining the manner of its use. The rate of grade on each main track must be shown, together with number of signals, derails, locks, etc., corresponding to levers in tower.

It is intended in this circular to state general rules, which will govern the construction of any proposed system of interlocking. The business to be handled, relative position and operation of intersecting lines, may require safeguards not mentioned herein.

The system of derailing, signaling and interlocking must be connected and worked, and be complete in each particular before it will be approved.

CHARLES HANSEL, Consulting Engineer.

APPROVED:

By the Railroad and Warehouse Commission.

J. A. PADDOCK,

Secretary.

ASSOCIATION OF ENGINEERING SOCIETIES.

PROCEEDINGS.

BOSTON SOCIETY OF CIVIL ENGINEERS.

OCTOBER 15, 1890.—A regular meeting was held at the American House, Hanover street, Boston, at 19:45 o'clock. Vice- President McClintock in the chair. Fifty members and fourteen visitors present.

The record of the last meeting was read and approved.

Messrs. Charles F. Baxter, Frank A. Bayley, Charles A. Bowman, Benjamin F. Goodnough, Ernest G. Hopson, Arthur C. Moore, were elected members of the Society.

On motion of Mr. FitzGerald, it was voted to take from the table *Seriatim*, the amendments to the Article of Association of the Association of Engineering Societies proposed by the Board of Managers. A lengthy discussion ensued upon the advisability of enlarging the powers of the Association and of the Board of Managers as provided in amendment one, in which Messrs. Allen, Brooks FitzGerald, Howland, Howe, Porter, Smith, Stearns and Tinkham took part. The motion to adopt amendment one was then defeated by a unanimous vote. After a short discussion the motion to adopt amendment two was also defeated.

Mr. Edgar S. Dorr exhibited and explained a practical diagram for the rapid determination of approximate sizes of sewers.

Mr. A. F. Noyes gave an account of the water supply of Newton and described in general the plan for enlarging the works. Mr. H. D Woods followed with a detailed description ot the covered reservoir and filtering conduit now under construction for that city.

Mr. H. H. Carter read a paper giving the history of the settlement of the embankment between Squantum and Moon Island.

Adjourned. S. E. TINKHAM, Secretary.

MONTANA SOCIETY OF CIVIL ENGINEERS.

OCTOBER 18TH, 1890. The regular monthly meeting was held in the office of Messrs. Sizer & Keerl. There were present Messrs. McRae, Foss, Smith, Hovey and Keerl.

On motion Mr. Foss was made chairman.

Secretary's report of previous meeting was read and approved.

Under the head of unfinished business, a letter was read from the Secretary of the Western Society of Engineers, asking that a committee be appointed to meet with a committee of that society and committees of other societies on October 14, 1890, to make arrangements for an International Engineering Congress to meet during the World's Fair.

Motion was made and carried that the Secretary be instructed to write the Sectary of the Western Society of Engineers, giving cause for the delay in answering his communication.

A letter from Mr. Bogart, Secretary of the American Society of Civil Engineers,

was read, giving price for transactions of his Society for previous years, and on motion was laid on the table for future action.

The application of Mr. Henry J. Horn, Jr., for membership was read and placed on file and the Secretary instructed to issue the usual letter ballots.

A letter from the Hon. T. H. Carter, M. C., was read, thanking the Society for printed copies of a letter, addressed to him, on the reform of public land surveys, stating that he would take pleasure in sending copies to each member of the Public Lands Committee of the House and Senate, and likewise to every representative from the States particularly interested in the subject matter.

A letter was read from the Engineers' Club of St. Louis, enclosing the report of the committee of that Club on the subject of affiliation with the American Society of Civil Engineers.

It was moved and carried that a committee of three be appointed to frame a bill for the protection of life from open shafts and prospect holes, and present same to the Legislature at its next session.

Messrs. Keerl, Hovey and McRae were appointed as such committee.

A letter was read from Mr. Benezette Williams, calling attention to certain amendments to the Articles of Association awaiting action of the Societies.

The amendments are found on page 589, volume 8, of the JOURNAL, December number for 1889. Motion made and carried that amendments be approved, and Secretary directed to notify Mr. Williams accordingly.

Adjourned. J. S. KEERL, Secretary.

ENGINEERS' CLUB OF ST. LOUIS.

332ND MEETING, September 17th, 1890. The Club met at 8:15 p. m. in the rooms of the Elks' Club, Vice-President Burnett in the Chair; sixteen members present.

The Secretary being absent, Mr. Melcher was elected Secretary pro tem.

The minutes of the 331st meeting were read and approved.

Mr. Richard Klemm was balloted for and elected.

Applications for membership were announced from Frederic Eugene Turneaure endorsed by J. B. Johnson and R. S. Colnon; and George Robert Olshausen endorsed by J. B. Johnson and C. M. Woodward. These were referred to the executive committee.

The report of the special committee appointed to consider and report upon the amendments proposed to the Articles of Association by the Board of Managers was read and adopted.

The resignation of Mr. Wm. H. Bryan as secretary, was read and accepted.

It was moved and seconded that the Secretary pro tem. write to Mr. Bryan a letter expressing the appreciation of the Club for his faithful services as Secretary.

A paper was then read by Mr. O. L. Petitdidier on "The Telescope—its Optical Qualities and Application to Measurements," giving the history of the telescope and its application to the uses of Engineers.

Discussion followed by Messrs. Johnson, Holman, Ockerson and Colby.

The executive committee was instructed to nominate at the next meeting a Secretary for the unexpired term.

Adjourned. CHAS. W. MELCHER, Sec'y. pro tem.

333RD MEETING, October 1, 1890. The Club met in the rooms of the Elks' Club at 8:20 p. m., President Nipher in the Chair. Mr. Melcher was elected Secretary pro tem.

The minutes of the 332nd meeting were read and approved.

The President announced that the Executive Committee had been unable to obtain a quorum since the last meeting and hence had not prepared letter ballots for Secretary.

Messrs. F. E. Turneaure and Geo. R. Olshausen were balloted for and elected to membership.

A communication was read from the "Western Society of Engineers" with reference to a Congress of Engineering Societies at Chicago during the World's Fair, and inviting co-operation of other societies.

It was moved and seconded that the Chair appoint a committee of three to attend the meeting at Chicago, Oct. 14th, to discuss plans for carrying out this project.

Messrs. E. D. Meier, Robt. Moore and J. B. Johnson were appointed on the committee.

Mr. Chas. I. Brown then read the paper of the evening giving an interesting account of the construction and reconstruction of a number of railway culverts on the line of the St. Louis & San Francisco Ry., with drawings illustrating the work. Discussion of the paper followed by Messrs. Johnson, Nipher, Crosby, Brown Bruner, Van Sant and Russell.

In discussion of general engineering topics Mr. Johnson brought up the subject of Poro's Telescope mentioned by Mr. Petitdidier at the last meeting. In using this form of instrument for stadia measurement the distance may be determined from the center of the instrument instead of from a point the focal length in front of the instrument. Mr. Johnson stated that Mr. Turneaure and himself had solved the equations proving that this instrument was mathematically correct.

Adjourned. CHAS. W. MELCHER, Sec'y. pro tem.

334TH MEETING, October 15, 1890. The Club met in the rooms of the Elks' Club at 8:10 p. m., President Nipher in the chair and twenty-three members present.

The President announced that the Executive Committee had been unable to obtain a quorum and made the suggestion that a committee be appointed to count the ballots for Secretary. On motion which was carried the President appointed Messrs. Gayler, Wheeler and Bouton. Mr. Melcher was chosen Secretary pro tem. and the minutes of the 333rd meeting were read and approved.

Mr. Jas. M. Sherman then read the paper of the evening, "Steam Pumping Machinery." Discussion followed by Messrs. Farnham, Sherman, Flad, Nipher and Chaphe.

The committee appointed to count the ballots for Secretary reported that Mr. Arthur Thacher was elected.

Mr. Laird exhibited specimens of paving bricks and clay from Galesburg. Ill. The bricks were said to have given good results at Galesburg. The cost of the brick is $9.00 per thousand f. o. b. Discussion followed by Messrs. Sherman, Laird, Wheeler and Moore.

Adjourned. ARTHUR THACHER, Secretary.

CIVIL ENGINEERS' CLUB OF CLEVELAND.

AUGUST 12, 1890.—Club met at 8:15, p. m. President Searles in the chair. Present sixteen members and two visitors. The minutes of the last meeting were read and approved.

A communication from the Western Society of Engineers requesting the Club to appoint a committee to meet in Chicago on Tuesday, Oct. 14, 1890, to aid in formulating a plan for holding an International Congress of Engineers at Chicago, in connection with the World's Fair was read, and the President was instructed to appoint a committee of three for this purpose.

The application of Mr. Geo. C. Lucas for active membership was received.

The President announced that the "Technischer Verein" would hold a convention in Cleveland before the next regular meeting of the Club.

The Executive Board was authorized to take the necessary action to extend the courtesies of the Club to the visiting scientists.

The paper of the evening was by Mr. James Ritchie, on "Some Recent Constructions of Railway Bridges" but as he was unavoidably absent it was read by Mr. Walter P. Rice.

After the reading of the paper there followed a discussion of the use of iron and steel in bridge construction, of kinds of steel to be used, relative lengths of plate-girders, and latticed bridges, and the relative merits of the pin-connected and riveted bridges.

The President then congratulated the Club on the success of the last meeting held during the hot months.

A. H. PORTER, Secretary

SEPTEMBER 9TH, 1890. Club met at 8 P. M., President Searles in the chair. Twenty-three members and five visitors present. The corresponding Secretary acted as Secretary of the meeting in the absence of Mr. Porter.

The minutes of the last meeting were read and approved.

A ballot was taken on the application of Mr. George Charles Lucas and he was elected an active member receiving all the votes cast.

The applications for active membership of Mr. James William Gallup, Assistant Engineer of the L. S. & M. S. Ry. Co., and of Charles Henry Benjamin, Prof. of Mechanical Engineering in Case School of Applied Science. were reported favorably by the Executive Board and laid over to be balloted on at the next regular meeting.

The President stated that the Executive Board had voted at its last meeting to ask the Club to select a day, for instance the third Tuesday of October, to be known as "Visiting Day," for the Club to visit in a body some manufacturing establishment or other place of engineering interest for the mutual benefit and better acquaintance of the members, and Mr. Barber made a motion to that effect, naming said third Tuesday as the day. Mr. Bowler offered an amendment substituting the third Tuesday of each month, for the third Tuesday of October; amendment lost. Mr. Eisenmann offered an amendment giving the Executive Board authority to establish such visiting days as they may deem proper; carried. The President then stated that the original motion by Mr. Barber had not been disposed of, and it was put as a request from the Board to the Club, to make the third Tuesday of next October the first of such visiting days, and carried. The Secretary read a letter from W. B. Ruggles, of Cincinnati, stating that the Engineers' Club of Cincinnati contemplate asking for admission to the Association of Engineering Societies, and asking for a statement of benefits arising from the Association, etc. Referred to Prof. Staley to answer.

A letter was also read from B. E. Fernow, Chief of Forestry Division of U. S. Department of Agriculture, submitting three copies of Bulletin No. 4 of the Division, containing a report on "The Substitution of Metal for Wood in Railroad Ties, by E. E. Russell Tratman, C. E," with a discussion of the subject by Mr. Fernow, and stating that members could be suppled with copies upon application to the Division.

The Secretary was instructed to send acknowledgment and thanks of Club.

The President appointed Messrs. C. M. Barber, W. P. Rice and John Eisenmann a Committee to meet with Committee of Western Society of Engineers and Committees of other Societies at Chicago, Oct. 14th, 1890, to arrange for an International Engineering Congress at the Columbian Exposition in 1893.

The President announced that owing to absence from the city and business engagements, Mr. S. T. Wellman had resigned the Chairmanship of the Committee on Mechanical Engineering.

The President appointed Mr. Walter Miller, of the same Committee, Chairman in place of Mr. Wellman, and Mr. E. H. Jones to fill the vacancy on the Committee

Mr. John Eisenmann made a verbal report on some features of the German, American "Technischer Verein" lately held in Cleveland, and gave details of some of the subjects treated by papers read at the meetings he attended.

The President stated that the amount received from sale of tickets by the Com-

mittee on the recent Picnic of the Club fell short $16.00 of the expenses of the affair and thought some action should be taken to help the committee make up the deficiency.

Mr. J. L. Gobeille at once started a collection and raised $19.00 from members present, which with $6.00 contributed by Messrs. Force and Vaughan of the Committee left a surplus of $9.00 after paying bills, which was left in the hands of the President to be used at some future social meeting of the Club.

The Club then listened to the paper of the evening by Mr. Walter P. Rice entitled "Lake Currents and the proposed opening of the Breakwater." A written discussion of the paper by Mr. John H. Sargent who was unable to be present was read by the Secretary. After an interesting discussion of the paper by several members including Messrs. Whitelaw, Force, Eisenmann, Gobeille, Searles and others, the Club adjourned at 10.45 P. M.

S. J. Baker,
Corresponding Secretary.

October, 14th, 1890:—Club met at 8 o'clock. Vice-President Gobeille in the chair, and fourteen members and five visitors present.

The minutes of the last meeting were read and approved.

Prof. Charles H. Benjamin and Jamer W. Gallup, were elected active members.

Mr. Herman, from the committee appointed to secure new Club rooms reported that no steps had yet been taken by the committee in the matter.

In reference to "Visiting Day" the chair stated that a number of manufacturing establishments had been written to, and that replies has been received in nearly every instance, stating that they would be pleased to have the Club inspect their respective plants. Among the firms written to were: The Otis Iron & Steel Co. (Limited), The Brown Hoisting & Conveying Machine Co., The King Iron Bridge & Mfg. Co., The Cleveland City Forge & Iron Co. and others.

The Executive Board recommended the election of Mr. Charles Wallace Kelly, and Mr. Frank Walter Wilson to active membership.

Mr. J. H. Sargent then read a paper entitled "Railroads; Past and Prospective," giving a very interesting account of many of the wonderful improvements that have taken place in comparatively recent times and predicting that on the railway of the future the trains will be moved by electricity.

After the reading of the paper there was an interesting discussion by Messrs. Herman, Bowler, Roberts, and others, after which Mr. J. B. Larned gave a brief description of the suspension bridge on Grand Ave., St. Louis, which was followed by a description of the bridge over the Ohio, connecting Cincinnati and Newport, now building.

On motion the Club adjourned.

A. H. Porter, Secretary.

WESTERN SOCIETY OF ENGINEERS.

273rd Meeting, Oct. 1, 1890.—The 273d meeting of the Society was held at its rooms, Wednesday evening, October 1, 1890, at 8 o'clock p. m., President L. E. Cooley in the chair, and some 60 members and visitors present.

The minutes of the September meeting were approved without reading and the Secretary reported the meeting of the Board of Directors at which the following members were elected.

Chas. E. Hopkins, Chas. V. Weston, Theodore Starrett, Jacob A. Harman, Henry E. Gamble, Ira Smith Dunning, L. C. B. Holmboe, Chas. J. Morse, Wm. E. Miller, Ridley H. Lawrence, Harold A. Boedker.

In reply to a call from the President for reports of Standing and Special Committees, Mr. Chanute, in behalf of the Committee on the Reception of the Iron and Steel Institute, read the programme as finally agreed upon, and explained the question of subscriptions and other matters connected with the reception.

Mr. Isham Randolph for the Committee on "The Chicago Railway Problem, etc.," stated that offices had been rented and that funds for the preliminary work had been received.

Mr. O. Chanute for the Committee on "Bridge Legislation" stated that the Committee had had some meetings. It has entered upon the gathering of data, and has succeeded fairly well in getting some of them. The Committee has undertaken to ascertain,—First, what legislation concerning bridges has been had in foreign countries, and it has obtained the legislation in Great Britain, France, Austria, and Germany, of which it will give an abstract in its report. It has also obtained the data concerning legislation heretofore proposed in the United States, and has also obtained data concerning the practice of the leading railroads in the United States, more especially in regard to bridge floors, which is considered the one important thing for legislation to touch upon. It will take some months for the Committee to gather all the data it wants to present to the Society, and it hopes that when it finally hands in its report, it will have gathered all the information necessary to arrive at a correct opinion of the subject, and to judge as to what legislation is best, and what is possible to accomplish.

Mr. Isham Randolph then read an interesting paper on "Railroad Signalling and Interlocking" which will be printed in the November issue of the *Journal*.

PRESIDENT:—We have with us this evening the Consulting Engineer of the Railway and Warehouse Commission, at whose instance this subject was largely brought to the attention of the Society, and who probably has some views to express on this subject, which we would be very glad to hear; but in addition to what he might wish to say in the matter, I think the Society would be pleased to hear in regard to what the legislation of the State and the policy of the Railway and Warehouse Commission contemplate, so that those who are not especially posted on this question can have some general ideas to grasp. We are not all posted on the technic of this thing. I shall be pleased if Mr. Hansel would take up that part of the subject and give us a little information.

MR. HANSEL:—I had no idea of saying anything to-night. The object I had in asking for a discussion of these topics was in order to help myself. The Commissioners, with the view of gathering general knowledge regarding all safety appliances, at my suggestion, authorized and ordered me to make a full and exhaustive examination of all safety appliances. You all know that that is an endless task to undertake, and which I could not accomplish. However, I have taken up the subject under three headings, one of which is interlocking. You have all seen the articles in Scribner, on Feats of Engineering, and also seen the article in regard to Safety Appliances. In that article the author claims Inter-locking is a feature of safety to the public. That is the primary object. At the same time, he says that the best engineers will not de-rail a train. It seems to me it we take out the factor of safety, it becomes a machine for the convenience of handling traffic, but we all know the engineers do not stop at the crossings. It is generally understood that where we have double tracks crossing single track of line, where the current of traffic is in one direction all the time on the double track, that it was unnecessary to have derails except on the side against the current of traffic. It has occurred to me from noting the operation of these lines that as soon as the caboose is over the detector bar, there is nothing to prevent the Tower man from giving a conflicting signal. I have accepted some of these plants but since that time, I have altered the requirements, so that it is necessary to put a detector bar on the opposite side of the crossing from the derail, so that a clear signal cannot be given when any car is on the crossing. I sent your secretary a copy of our requirements. There are other things which come up in Inter-locking, in which the danger of the crossing adds to the danger of the whole, and for that reason, we introduce another feature in our requirements, which provides for nother point outside of the actual crossing. Now the law of 1889, which gives the commission power to authorize the operation of

Inter-locking, simply states that the crossing shall be protected, but I think you will all uphold me when I take the position that it would be folly, and unwise to lose sight of everything except the crossing. We might, in protecting it, introduce a new element of danger, which would exceed the old danger of crossing.

The object of all these enquiries is that I have been touching them up on all these things, and I am anxious to have our commission in Illinois at the head if we can. Instead of following other States, I want them to lead, and it was with the idea of becoming familiar with all safety appliances which had any feature to their credit, that this report was asked for, and I would be glad to furnish copy of our report, although I have no idea that it would be of any information, except that I have gone over the laws of all the States, and taken note of any action that any State has taken in regard to safety appliances.

Illinois has never taken any action in the matter except in 1874, when they required that all passenger cars should have automatic couplers. That is the only action that Illinois has taken with regard to safety appliances, and there will probably be some demand in that line at this next session, and we intend to have a report on hand, so they may have the information if they desire to act in the matter.

Now, as regards, couplings,—we have all discussed that I suppose, and I have given it considerable attention. I have a great deal of respect for the action of the car builders, and think that while we have not yet got the ideal coupler, that if we settle upon a type, the inventor will give us the proper design. As uniformity in everything is what we must ask for, I am against any action of our State Legislature as regards any safety appliance which is not only inter-state, but inter-national. We all know that our traffic is not confined within the United States It goes to Canada and old Mexico, and any law that any State would pass would be an evil. I have advocated the idea that if the Congress of the United States would pass a law requiring couplers and air brakes of a certain style on all cars as they were repaired, and all new cars that were sent out, and the provisions of this law were carried out in each State through its commissioners, it would be a good thing. Massachusetts and some other States have asked Congress to authorize the Inter-State Commerce Commission to handle this subject. I think if the commissioners of all the States were authorized to act in this matter, they could do it. Figuring 557 cars for each 100 miles of railroad operated, we would have something like 55,000 freight cars in Illinois, and there are 237,000 freight cars owned by companies operating in Illinois. If we count on 19 engines for each 100 miles of operated line in Illinois, we would have 1,800 engines, which to equip with air brakes on engine and cars would cost over $3,000,000, or 8½ per cent. of the gross freight earnings of all the companies of Illinois, so that we see that we cannot command the introduction of any device of this kind except by degrees.

PRESIDENT:—I think we have all been very much interested in what Mr. Hansel has had to say. There were one or two questions which occurred to me while he was talking. I suppose your idea would be that all this authority, in place of being enacted in specific legislation, ought to be lodged in somebody who has discretion to apply it, that it can be made to harmonize with other States, so that each State will not be adopting service devices which will not be in harmony with inter-state communication.

MR. HANSEL:—The Master Car Builders have been the only society who had nerve enough to come forward and say "We will adopt a certain line of car coupler," a certain type of air brake. Commissioner Mason says, in his annual report of '89, that the introduction of automatic couplers has not been attended with the result he hoped for, and I think that no good will come out of the automatic coupler question until Congress says that the type of coupler shall be so and so. I do not mean to say that the style and device should be exactly so, but the type shall be so and so. After they have decided that question it is easy enough for each State to act in harmony. Otherwise, the State of Michigan will allow them to put in any one of the thousand types that we have, whereas Ohio would select a few and Indiana would select a few,—all different, so that it does not seem to me that any action of State Legislature will ever solve the question.

PRESIDENT:—Is the question of safety of bridges assigned to your Commission?

MR. HANSEL:—Yes,—I attempted to cover everything,—with a blanket. I took up that subject in this way. The State of New York has caused drawings and reports of the age and kind of every bridge in the State to be made. Now, while the engineering skill brought to bear in getting up this report was considerable,—the moral effect was considerable, because a great many companies knew that their bridges were not entirely safe, and added to their strength before they made that report to the engineer in charge. I have advocated a similar policy in Illinois,—that every railroad in Illinois shall tabulate, in the order that they stand, every bridge. It was not a Forth nor an Eads bridge that caused the Chatsworth disaster, and it occurs to me that the small bridges need more a ttention than the large ones. I ask that all the particulars be furnished and filed in the office of the Commissioners. As it is now, the Commissioners only take cognizance of such factors in the physical operation of the road as they are called upon: that is, if anyone enters a complaint, they take it up. We have 9,936 miles in Illinois, besides 700 miles of double track, and considerable sidings, so that to inspect each mile of that road, and keep an eye on all the bridges, you know would take a considerable force of engineers.

PRESIDENT:—Are Inter-locked crossings becoming general?

MR. HANSEL:—Since the first of this year I have inspected nineteen machines, operating 565 levers. The Chicago & Alton say they are going to inter-lock everything in the State, and the Illionis Central are getting all they can done in that line. So far as I know, there has not been one accident through the fault of the interlocking.

There is one thing that I took up in connection with the Inter-locking, and that is that there are no reports made to the Commissioners of the operation of the interlocking. After it is accepted, we take no further action in the matter, and I think that they should give us a monthly report. Now, the Commission is empowered to order all these things, but we have not got down to it yet.

MR. RANDOLPH:—Mr. Hansel was speaking of the matter of protecting double track crossings I think I know the very crossing to which he refers, and I was down there not long ago when a train passed over that crossing,—got clear of the detector bar on the south side, and then backed down and stood over the crossing, and there was nothing to prevent the man in the Tower from giving the signal on the other road.

Another question we had up was the proper position for the Guard Rail,—whether on the inside or the outside. After a general consultation it was decided that the inside was the best, but I have been talking, since, with the Superintendent of one of the roads, and he tells me that his experience is that it is not the best. He says it should be on the outside.

MR. HANSEL:—In speaking about the Guard Rail,—we had eight inches for the distance between the heads of the stop rail and the Guard Rail, and in my requrements, I have added an inch to that. I don't think it makes any particular difference whether it is on the inside or the outside

Speaking of that Detector bar on the opposite side of the crossing, I did not understand whether my friend Mr. Randolph advocated that idea, or whether he was against it. I went down to Madison on the Illinois Central, with the Chief Engineer, Mr Moore, and there were some things he did not have in, and as I had not ordered these bars before, I told him I would not say anything about it at that time but hereafter, I wanted them in. He said, "That is a good idea, and I also want them in," and he ordered them, and they are in now. They operate with the home signal and you cannot get the home signal until you throw your detector bar on the other side of the crossing, and you can't do that until the car is over the crossing.

MR. RANDOLPH:—I am thoroughly in accord with you in believing that they should be on both sides.

MR. HANSEL:—I took up drawbridges with the other hundred and one items. In the law of 1889, there was no provision made for inter-locking on draw-bridges. As the law now stands, we should come to a stop before crossing. There are a great many of such bridges in the State of Illinois that are not operated as the law intended, and I have advocated the addition of the inter-locking law of '89 providing that draw bridges be so equipped. At Bridgeport, Chicago, is a very fine ma-

chine. The tower is over the engineer's house, and the engineer can make no effort to operate his engine to turn the bridge until he is allowed by the inter-locking devices. The connections of the bridge are all made of inch gas pipe, and eyes and hooks and everything has to be placed before they can open the bridge. Under such conditions they claim it is much safer to allow trains to cross an inter-locked bridge than to have them supposed to stop before one that is not locked, so I propose we shall have such an act as will allow railroads, by a small expenditure, to inter-lock bridges and go over them without stopping the same as grade crossings.

MR. STROBEL:—I have nothing to say except that I should like to ask Mr. Hansel whether there are any de-railing devices required for drawbridges.

MR. HANSEL:—When these devices are used, the commissioners have no authority to authorize trains to cross the bridge without stopping first. The only thing we expected was that the interlocking would protect them, but if the law is enacted so as to permit them to cross the bridge without stopping first, it will save them all the stops at the bridge. I don't have any idea that they stop at all but under the law they would have to, even though it is inter-locked. I would ask that you call on the different members for their ideas on any safety device that they have in their mind, either couplers or any other device. The State of Connecticut, I think it is, has asked that a hand rail be put upon the freight cars. I should like to get some idea on that, and other appliances, if you have not any other business on hand.

MR. WILLIAMS:—I am not at all familiar with inter-locking devices, but dealing with men who do routine work, I find accidents occur from forgetting to do the little work they have to do. These inter-locking devices I have read of, and that have been discussed here tonight,—as I understand them, require a lever to move a switch, and then an additional lever to move the signals. Now I would like to ask the gentlemen who are posted on these matters, if any effort has been made to reduce that to one motion. I have read recently of the devices that were used in handling the guns in our war ships,—some of the latest improved devices, and they so arranged the lever that it would require a man of practically no intelligence to produce the movement that he wanted, the same as though he caught hold of the lever with his hands and lifted the article direct. It requires quite a delicate mechanism to bring about that result. It occurred to me that it was possible,—whether an effort has been made in that direction I do not know, to make the one lever move all the signals necessary to one adjustment for the passing of trains in one direction. It seemed to me that would be a desired result in connection with inter-locking devices. Information has also been asked regarding a hand rail at the end of the rs. I know very little about that, more than the danger and difficulties that are connected with the coupling of cars,—and that the hand rail is a very desirable thing. It frequently happens that men are required to be about cars that are not professional railroad men. They get in between the cars and a hand rail device it seems to me would be a very desirable thing to have, and the switchmen, in their association have recommended it as one of the desirable features to add to car construction, and it adds very little to the cost.

PRESIDENT:—What system is used in East St. Louis.

MR. HANSEL:—That is pneumatic, but it is a compilation of ideas that have been from time time added. I really do not know very much about it because they have added to it from time to time, as their ideas have enlarged.

In answering the question in regard to putting more on one lever, I would say that the tendency is to put too much on a lever. It is easy enough to hang them on. I suppose that the idea in having them on one lever was to simplify the thing so that the man could not organize an accident. I would say that before he can give the safe signal, he has to throw his de-rail lever, so that he can not give the safety signal without it is safe. It is a mechanical impossibility, so there is no object in adding too much to one lever. In a comp icated switch, it is nesessary to have more than one lever. I would say that Illinois has 10 per cent. of the inter-locking machines in the United States.

A circular comprising the requirements to be complied with in the construction of Inter-locking, signalling and derailing devices at grade crossings of intersecting

lines of railroads in the State of Illinois, issued from the office of the Railroad and Warehouse Commission, Springfield, Illinois, will be printed in connection with Mr. Randolph's paper and the discussion in an early issue of the JOURNAL.

After some closing remarks by the President the meeting was adjourned.

JOHN W. WESTON,
Secretary.

ASSOCIATION OF ENGINEERING SOCIETIES.

ORGANIZED 1881.

Vol. IX. December, 1890. No. 12

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WATER SUPPLY AND ITS DEVELOPMENT FOR SMALL CITIES IN THE WEST.

BY WYNKOOP KIERSTED.

[Read before the Engineers' Club of Kansas City, Nov. 7.]

The object of the present paper is to consider in a popular way the development of public water supplies; particularly with reference to the many progressive towns in this portion of the West.

So many towns have failed to realize their anticipations in securing a public water supply, that the town authorities seem, either to have been ill-advised, or, to have misapprehended actual conditions; some cases of failure are directly due to inappropriate methods of development.

An experience gained by one or several successive failures is expensive and undesirable. Small towns can ill afford to pay for information on such matters two or three times its market value. It is much better to preclude failure by a thorough and systematic investigation.

No matter what the size of the town may be, this question of water supply so involves the health, happiness and protection of the community, that it demands the best and most disinterested consideration of town authorities.

Small communities relying on cisterns and wells, often cling to them when the growth of the town should encourage better protection. Cisterns are usually for the storage of rain-water, and many suppose that from this source comes the purest and best supply for domestic uses. This view is all very proper, when it refers only to the use of water for ordinary

kitchen purposes; but, if it includes its use as a potable water it is an erroneous one, for the reason that noxious and soluble gases and fine dust emanating from animal and vegetable life, from the decay of organic substances, from the disintegration of mineral matter and from fuel combustion, are as native to the air as sediment is to a flowing river, and the rain as it descends, absorbs these atmospheric impurities, surrounds them with conditions favorable to chemical action and reaches the earth in a state of greater or less impurity.

Even this source of pollution need not render rain-water in the vicinity of small towns, unfit for a general domestic use, were it kept from other contaminations; but, on the contrary, by contact with painted and dirty roofs and gutters on the way to the cistern, and the great liabilitiy of these receptacles to the percolation of surface water; additional sources of pollution are encountered.

Within the cisterns the conditions are unfavorable for the circulation of air and water, and any gases arising from the enclosures are readily absorbed. Thus it is that rain water, by the time it is used can become exceedingly impure.

Open wells draw towards them the ground water from considerable distances in all directions, and, when in the vicinity of cess-pools and privy vaults, become a receptacle for their subsurface drainings. It is commonly thought that water by percolating through the ground will become pure. This idea, however, must have its limitations, since water to be purified by natural filtration must pass through porous and well drained soils permitting of a free circulation of air, and the process of oxidation; but when draining through or from deposit vaults into the deep sub-soils, it is simply filtered, and may enter a neighboring well perfectly clear, but most dangerously foul with matter in solution.

Even drive wells, with an iron-encasing tube, are not exempt from such dangers of pollution, because there being no storage capacity to a drive well as to open wells, a depletion of the soil extends in all directions immediately upon draft, and this depletion is more extended, the greater and more continuous the operating power attached to the well, so that it is only necessary for the drainage from vaults in the vicinity to reach this affected district in order to find access to the well.

Cisterns and wells are of course a necessity in the early history of a community, but they demand constant vigilance as the price of freedom from contamination; and in estimating the quality of the water from either source, it is never safe to depend on appearances, for though the water from them may be clear and sparkling, it is not, for all this, necessarily pure; even sewage may be clear as crystal.

Both methods of water supply can well be discarded for everything but the ordinary house uses, as soon as the town can afford to procure water from some safe and reliable source.

The waters of drainage and percolation, collected naturally in rivers, lakes and in porous sub-soils, are the immediate source of large local supplies, and may be divided into surface and sub-surface supplies, and even these facilities are more or less limited according to the locality.

Of the surface supplies, the best comes from some one of the great rivers. These waters, by flowing over and through uneven beds of silicious sand and gravel of considerable slope, and by being brought continually in contact with the air. are freed from organic matter by oxidation. The retained impurities are chiefly sediment in suspension, which are readily disposed of by settlement in basins or by filtration. What hardness there may be in such waters is usually not sufficient to interfere with general domestic service. The intake from such a source should be located in a main channel, and at a point above the town, where pollution from sewage and manufacturing waste, cannot reach.

Lakes in this central western district, if they exist at all, are usually unfit for furnishing good water and can scarcely be considered here.

Circumstances sometimes favor impounding reservoirs, which store surface waters collected from a more or less extensive water shed. Such supplies are desirable where the impounded water can possess depth, at the expense of superficial area; and can be free from contact with vegetable soils and polluted surface drainage. When the drainage valleys are broad the stream burdened with sediment, the vegetable soils deep, and the subsoils porous, the conditions are very unfavorable for the construction of dams and the storage and maintenance of pure water.

Many inland towns are so situated that surface water, either cannot be obtained at all, or it is at an expense beyond their present means; consequently resort must be had to sub-surface supplies; and these may be both from deep and from shallow sources.

The deep sources furnish water by means of artesian wells, from the the ancient geological formations, consequently it is liable to the impregnations of mineral matter.

The shallow supplies, often in considerable quantities, come from the drift formations of sand, marl and gravel from 50 to 150 feet in depth, and are usually good for all house purposes.

In locating a water supply of this kind, caution is to be observed, for absolute reliance on a yield from such a source is extremely hazardous unless preceded by a thorough and skilled investigation.

In the first place the laws governing ground water flow are to be strictly observed, and are practically the same as those governing the flow of surface waters. The movement of the water through the ground, however, is very slow, due to the great resistance of the soil; and this resistance varies with its degree of fineness—for instance: water will pass very freely through a mass of boulders or coarse gravel; more slowly through sand; the rate of flow decreasing as the material becomes more finely divided; clay permitting very little to pass.

Much also depends on the extent of the water bearing material; whether it is an extensive reservoir, holding water collected from many square miles of water shed, or is simply a pocket supplied in the immediate locality to become exhausted by a short season of pumping or during a drought.

It is evident from the character of such rivers as the Platte, Republican, Kansas and Arkansas, that the porous soils under and on either side of them must be in a continual state of saturation, and constantly trans-

mitting the waters collected from rains on inland districts; otherwise the water in the river basins would entirely disappear by downward filtration. The fluctuations of the rivers depend largely upon the degree of this saturation, and upon the extent of these storage reservoirs.

Generally in these broad valleys almost inexhaustible supplies of water can be obtained, in degrees of purity depending upon the amount of vegetable, animal and mineral matter that is encountered in the soils. The same is true of the tributary streams and valleys, except that their supplies come from more limited water sheds, percolate nearer the ground surface, and are consequently more affected by drought.

Inland towns can often be supplied from the same subterranean reservoirs as the river towns, but in this case the depth of penetration is usually greater, with a proportionate increase in attendant risk and expense.

It may seem that these few statements of the general distribution of a ground water supply, are opposed to the necessities of the tests heretofore referred to, but this is only apparent; for, while a knowledge of the geology of the country, of the meaning of surface appearances and of the existence generally of large subterranean reservoirs, is essential, and suffices for predictions, it is not positive information. There is always a lack of homogeneity in the deep sub-soils, faults in the geological structure, natural upheavals and other disturbances, which, like boulders in a surface stream, so prevent an uninterrupted flow, that tests in any locality are essential to establish conclusions. When so much depends on investigation and actual test before the location of a water supply and the means of developing it can be settled, it is difficult to tell why it is that communities will often be satisfied with a sort of "Witch-Hazel" location, and accept almost any device for securing the water, without a proper consideration of its adaptation to existing conditions. It is to be regretted that such cases are not few, and always involve a fruitless expenditure of public funds.

The common practice of locating a water supply on the public square, or on some vacant lots within the corporate limits of the town, is a most precarious proceeding. Usually it is for no other reason than to reduce the first cost of the works, or because the man who makes the investigation does not receive remuneration enough to pay him for the trouble of investigating a water supply outside the town limits. While considerations of economy are good, and are particularly necessary with small communities; they lose all force and argument when opposed to the health and comfort of the public. This water must surely be drawn from under the town, and most certainly will be polluted by the drainage from privy vaults and cess-pools. This danger has undoubtedly received little thought from the authorities accepting such a location, and no doubt many will scout the idea, but from the very fact that it is a danger, a positive danger, unseen and unfelt until it appears as an epidemic among the people, renders the duty to avoid it an imperative one.

As a matter of fact, a public water supply is usually from the deeper water bearing strata, which are often separated from each other by layers of clay or a mixture of clay and sand, but frequently of insufficient thick-

ness to prevent inter-communication. A circulation of water which may have been impracticable or impossible before the construction of a system of wells, is, by their existence in many instances, made not only possible, but probable: for the reason, that in piercing the various strata, a channel is opened for the passage of the upper water to the inlet of the wells.

A continuous draught drains the surrounding ground for many hundred feet, producing conditions favorable to a downward percolation of water, so that any drainage from underground receptacles of filth, by the slow process of filtration, is liable to reach the affected district and ultimately to find access to the homes of the community.

As a rule, the best location for a water supply is in the main drainage valley, or in one tributary to it above the town site, for there the danger from underground pollution is diminished, and the expense of interception the least. Objections are often raised to such a location near a stream, because the water in the river, by an occasional foulness, may be liable to taint any supply in its vicinity. Such objections, though plausible, may frequently be rejected because experience in various instances has shown that filter galleries, even though located close to a river and below the low water line, receive the greater part of their water from the land side.

Though the water in a filter gallery or system of wells fluctuates with a rise in an adjoining body of water, this does not prove an inland flow, but, as nearer the fact of the case, that this rise dams the approaching water in the soil, causing it to rise therein to accommodate itself to the new conditions:—as for example—the water in wells sunk in the sand closely bordering the ocean, has been found to fluctuate with the tide, while maintaining its freshness; also in a very cold climate the ranges of the temperature in the water collected in an uncovered gallery, was noticed to be very small, compared with that in a river bordering the gallery. No doubt, there is always some inland filtration at times of a sudden rise in a stream, the extent depending on the condition of the soil at the time: but the danger of fouling a well-located water supply in the neighborhood is very slight.

As has been said, the only way of finally determining a water supply after the site has been selected, is by actual tests, and such tests must be manipulated in a very careful manner or the results obtained will be overestimated.

A good way to make these is as follows: Sink an open well, three to five inches in diameter into the water bearing strata, remove the earth within the tube by means of a jet of water forced through a small pipe, one inch to two inches in diameter, by a steam pump. By this means the character of the soils passed through can be observed. At various distances from this well, and in at least two directions, drive small pipes 1½ to 2 inches in diameter, in line, to the same depth as the first well, and so as to permit free access of the water at the bottom. A small pipe for a pump connection can be inserted inside the large well and a pump attached. For this purpose a steam pump is preferable, or, one that will permit of a continuous

pumping for any length of time, practically fulfilling the requirements of actual service.

The fluctuation in all the wells, should be carefully noted at stated intervals and at variovs speeds of operation; the amount of water furnished can be measured by any convenient and reliable means. Whenever pumping ceases; the time required for the water to assume its original elevation in the wells, and the rate of change in this transition, is to be carefully observed.

It will be noticed that it takes the water in the ground considerable time to accommodate itself to any change of conditions, so that for certain results, long periods of pumping are necessary, and for this reason, the work should not be hurried.

Frequently several water bearing strata will be encountered separated by layers of clay, the upper ones being generally supplied from local watersheds and the soonest affected by draught and drought, while the deeper ones may collect water from a very large collectable area, and give a large and unintermittent yield. It is best to penetrate these deep and more extensive reservoirs to insure success.

That such tests are the notable exception throughout this country, is true, and with the present haste to develop a scheme as soon as decided upon, the disinclination to spend money on preliminary investigations, is very strong.

When properly made, they require a reasonable expenditure of money. The methods suggested, however, are not those to be put into practice by the novice or ordinary well-digger. The required plant can be found in any town, but the man under whose supervision the work is to be done, should be a specialist, whose study and experience makes him familiar with all questions of water supply, the laws of flow, the usual conditions of ground water storage; and one who is trained to minute observation and analytical methods of reasoning.

When a general public sentiment favors a water supply, the time for action is at hand; not, however, in a way to make a public issue of the question for the time for such decisive action is not propitious.

The usual custom of appointing a commission or committee to investigate the matter is a very good one; and their trip around the country to inspect various water works, gives them a knowledge of the subject, which will be of great assistance to them in their future duties. It is serviceable this far but no further. It is surely a mistake to let such an investigation conclude to them that a system of water supply or water works in any neighboring town, is exactly what is wanted in their own town, and so recommend to the people or Common Council: for, as yet, there is nothing to show its adaptation to local circumstances and conditions.

The best way for such a committee is, in the very beginning of their work, to select a competent engineer to study the question with them; to determine by necessary tests the best locality for a water supply, its quality and amount; and the best means of developing it. Let him submit a report, with an estimate of cost of the entire water works, best adapted to the needs and means of the community. This puts the matter in a tangi-

ble form to present to the public for discussion and vote. They know then just what they are doing, and how far they can carry their undertaking.

Such a preliminary investigation is not putting the people to any extra expense, for, it will have to be made before any reliable and complete set of plans are prepared, and the proper time to make it is before any popular vote is taken on the issue of bonds for the work, or any franchise granted to a Constructing Company.

In most cases where a franchise is granted the people cannot be too particular from where their water supply is coming and how it is to be preserved from contamination. Such an investigation and report as the one suggested, is a community's safeguard; and if municipal authorities would take such a rational view of the case, they would often save themselves vexations, delays and embarassing failures. If some method of this kind is not adopted, but the works projected and constructed in an unsystematic way, it is simply a question of a few years before the expert will be called to perform the very work that should have initiated the enterprise; and it may be at greater expense to the City, for, remodeling of a plan is by no means economical or satisfactory.

Committees who have located their water supply in the corporate limits of the town, where the soil is for years liable to defilement whether the town be sewered or not, have particularly this question to consider in a two-fold way. First. Ground in a town is expensive, and they usually have made little or no provision for the future extension of their works. Second. The location is so opposed to any proper sanitary regulations, that it is only a matter of a little time before a healthy public sentiment will fully appreciate this circumstance, and compel a re-location away from all possible chance of such foul pollution.

The method of development, as well as the location of a water supply, is a fundamental consideration, and is to be studied as an isolated problem, as far as the most feasible adaptation of a means to an end is concerned. It is bad policy to assume, as is sometimes done, that every means of developing a water supply, is worthy of a general application, even over a limited territory: because it has been successful in any one or two places. This is simply "putting the cart before the horse." The condition and peculiar requirements of the town and surroundings must first be determined; then apply that method most suited to the location.

In this section of country where the supply comes from a river or a reservoir connection is usually made directly with pumping machinery. Sometimes auxiliary filters are constructed in the banks, but experience has shown that these very often become useless by clogging with silt, and that they need constant attention. Artificial filters are now constructed by several companies, and great pains is being taken to make them successful as an attachment to a water works system.

Sediment is very readily disposed of by settling in basins properly capacitated to the size of the water works system.

When ground water is the source of supply, resort is usually had to infiltration galleries; large openwells, systems of drive wells arranged in gangs

and bored wells, sometimes the last of large size; each well fitted with an independent steam pump.

Infiltration galleries are usually constructed in the porous material near a river. Such galleries should be kept covered, for the collected water, being in reality filtered, is liable to pollution if exposed to the light and heat of the sun.

Open wells are one of a variety of infiltration galleries covering a small area of ground, but penetrating deeper to reach a suitable water bearing strata; in relation to them it has been determined that the bottom area alone can be depended on to furnish water.

Thorough tests should precede the sinking of such wells, so that the various materials to be encountered, and their depth, are definitely known and the most satisfactory point of stopping the excavation thereby determined.

Serious mistakes have frequently been made by unintentionally uncovering deep beds of quicksand or clay, which a little knowledge in advance would have prevented.

Perhaps the best example of drive wells arranged in gangs is the system used in Brooklyn, New York. Here the wells are in pairs on each side of a main suction pipe.

In distributing drive wells along a pipe or in any manner to draw water from the ground, it is necessary first to know the maximum demands on the system, the rate at which the soil is capable of furnishing water, and he depth of the water bearing strata. No well should, during its maxitmum draught, approach the limiting capacity of the soil to furnish water; nor should the draught be so severe as to permit the hydraulic grade line to fall below the top of the entrance to the pipe, as this will constantly impair its action.

As an example of what an improper distribution of wells will do, a case may be cited where a failure occurred due to the incapacity of the soil to furnish water. In this case the wells, about thirty or thirty-five in number, were arranged in a circle 12 feet in diameter, all having entrance to a tight (?) drum. Under a slow rate of pumping they operated very well, but before the draught reached the specified requirement, one million gallons per 24 hours, the supply failed.

There was water enough in the sub-soils, as had been determined by experiment, but the fineness of the material prevented a flow rapid enough, to supply the demand from so limited an area of pipe distribution. One-third to one-half of the drive wells were inoperative. Had the same number been properly distributed the result would certainly have been very different.

Various methods of distributing the wells are pursued, but unless good judgment is shown in the adaptation of the method to the conditions and in their mechanical adjustment, they fail to give the best results.

Bored wells 5″ to 8″ in diameter are sometimes used, when the water bearing material is at a considerable depth, each well being supplied with an independent steam pump. Such plants, being low service, require a storage reservoir of considerable capacity at the pumping station, additional

high pressure pumping machinery for the distribution system, and large boiler capacity. The operating expenses are necessarily heavy, due to so many independent pumps, and the large amount of fuel consumed in the manufacture of steam. Each of these methods of developing a water supply has its adaptation, but none can be recommended for any general use. In fact, it is not difficult to conceive of conditions, liable to be encountered, where each may, in turn, have superior merits, although instances, where the last method can be economically and advantageously applied to water works are exceptional. Sometimes a combination of two or more methods produces good results.

A choice of method, whether mentioned here or not, depends upon so many things, chiefly upon the requirements of the locality, as developed by test, that few suggestions can be given. It is best to rest the matter with a competent specialtist, who is familiar with all these things, and let him arrange and design the plant. Such a disinterestness is necessary in the adviser, that he can investigate the matter for the public good and not be biased by personal interests, in patented devices and so called system of water works.

By looking over official records and the results of Health Commission investigations the proof will be found ample to justify the most vigorous protests against the use of water from wells or in the immediate vicinity of any town. It is a historical fact that the health of cities and towns is largely controlled by the source and character of their water supply, and thousands of cases of cholera and similar diseases are directly traceable to a water supply contaminated by cess pool drainage and fœcal matter. It is not necessary to cite the many proofs of this statement. One has only to read to find enough to convince the most skeptical. It was once stated by the Mayor of New York namely "When cholera last visited our city every case could be traced to the use of well water, where not a single case occurred where Croton water was used." In the terrible scourge in the small town of Plymouth, Pa., in 1883, the death of every individual could be directly and most conclusively traced to a contaminated water supply eminating from a single patient of typhoid fever.

THE STATE AND THE RAILROADS.

By L. P. Morehouse, Member Western Society of Engineers.

[Read November 5th, 1890.]

The word "Socialism," a few years ago, was a sort of red rag, that whenever brought into public notice excited the virtuous indignation of all good citizens; but, of late, its obnoxious character has largely disappeared, so far as reading and thinking people are concerned; the point of view having changed, and the lurid color being softened, under certain aspects, almost if not quite to a rose tint. Some of us were brought up on the wholesome democratic doctrine, "the best government is that which governs least," but now-a-days there are multitudes of unbelievers who make no bones of scouting this former corner stone of American political orthodoxy.

The wonderful changes—most of us call them advances—in our material civilization during the last generation have obliged us to revise our political ideas, in some degree, and to see that some of the principles of govenment which seemed eminently sound to the fathers are not perfectly adapted to the changed social conditions of the children. It is easy to understand that the rules agreed to by the people of the United States for mutual protection and restraint when they first began to formulate what we call "laws," however suitable and efficient for a people of little wealth and simple habits, with no large cities, and almost exclusively agricultural in their pursuits, would fail to further the peoples' best interests when the struggle for existence on the one hand gives to Poverty the barest livelihood, and, on the other, the thirst for riches culminates in the acquisition of great wealth, making an impassable and ever widening gulf between the rich and the poor; when the privation of one class is emphasized by the luxury of another; when the integrity of self respecting citizens who both made and observed the laws is replaced by the corruption and venality which always attend the electoral franchise when it is in the hands of the ignorant, the debased or the vicious.

Under these altered conditions, I say, it naturally follows that we are willing to recast our original views and admit that "the best government" must be positive rather than negative in its laws. But the extension of the powers of a popular government means that the people in their corporate capacity are taking upon themselves obligations that primarily pertain to individuals. So long as our laws are purely restrictive we think little of any "socialistic" tendency in them, but, a moments consideration shows that when the state or the municipality enters upon a positive program it has made a step in the direction of Socialism. In some things we admit that Socialism is a success. We would not dispense with our public school system nor with paved streets, nor with sidewalks, nor with street lamps, nor with the public library, nor—I blush to confess it—even with the band playing in the park:—all paid for by the taxpayer. Having

gone so far it is easy to believe that we shall surely, if slowly, relegate to the government many things which are now considered wholly within the scope of private enterprise. It is unnecessary to speculate as to all the specific duties the State will undertake, but it is probably safe to say that these will be assumed one by one under the pressure of necessity, and under the governing principle that *the State may do for its citizens those things which can be done, on the whole, better by the government in its corporate capacity than by an individual or by a private corporation.*

The urban governments will continue to take the lead, as the public necessities from time to time shall force them to action; the experience of large cities already having demonstrated that the enterprises taken under their direction result in greater economy and better service to the public than when such are controlled by private parties or corporations For instance, no disinterested citizen will claim that it would be wise on the part of the City of Chicago to give up its water supply to the control of a private company. It will soon be admitted that artificial light and heat should also be supplied by the city government, for in no other way can the rights and interests of the public be so well maintained.

The general government will move more slowly, but, with the progress of urban socialism, there will be an increasing willingness on the part of the people to allow the federal authority to exercise functions which have heretofore been latent or emphatically denied. Already there are two matters of vast importance which are being freely discussed and which are liable at any moment to come to the front as active political questions. One is the acquisition of the telegraph system by the federal government; —the acquisition of the railroads of the country is the other. As to the former, the analogy between the telegraph service and the postal service is so great that it is not difficult to believe that the people may readily consent to give the government the monopoly of both. Apparently there are no good arguments against government ownership that do not apply to one of these branches of the public service as forcibly as to the other. The railroad problem, however, is not susceptible of an easy solution. Theoretically, it may be, the premises warrant the conclusion that government ownership would be largely in the interest of the people. The time has passed when it can be seriously argued that the railroads may conduct their business entirely independent of government control.

Being purely the creations of the State they are necessarily subject to such restrictions as their creator may impose, and, further, having been granted their corporate rights not only that their owners may engage in a legitimate business and derive an income from it, but that the general public may be benefited, it is eminently reasonable that the people should be protected from injustice on the part of what must always be more or less of a monopoly. This proposition appears self evident when we remember that under existing social conditions the whole business world depends for its health on that regular circulation through the arteries of commerce which normally pulsates with clock work regularity over the net work of railroad tracks that vein the continent. It is vital to the people of Chicago and of every great city that the railroad service centering in their city should be

as regular, as certain, as the strokes of the great pumps which day and night, force the lake water through mains and pipes to their dwellings, shops and factories; as essential as the steady flow of the mountain stream diverted into its artificial channel is to the oasis which without it would lapse into its original status as a part of the arid Arizona desert.

The business of transporting and exchanging the varied products of the country is now so intimately interwoven with all other kinds of business that a general paralysis of all the industries of the country must necessarily accompany a similar condition applied to the railroads. And whatever irregularities even attend the operation of the latter are keenly felt by all other branches of business. Therefore, in the interests of the public the State wisely claims and exercises a control over the roads in their dealings with the people.

So far, this control has been almost exclusively used in the attempt to protect the public from business oppression or extortion, although to a limited degree, police regulations are in force, looking to the greater safety of passengers and employees. But between the present system of limited control and a full ownership by the State, there is a wide gulf, and at this writing it appears safe to say that the natural conservatism of the American people will prevent for a long time the acquisition of the roads by the public. That this will eventually happen is not so difficult to believe after reading the recent annual report of the president of the Chicago & Alton Railroad Company. Mr. Blackstone there takes the position that the restrictive influence of the government has been so injuriously exercised, and will so constantly extend in this direction, that the roads cannot long be operated by their present owners without running into irretrievable bankruptcy.

He therefore urges the government, as a matter of simple justice, to purchase at a fair price the property it has ruined, and to operate this itself in the interests of the public. While the financial and administrative scheme which Mr. Blackstone proposes is plausible, yet its chief excellence is, probably, that it shows a readiness on the part of the existing corporations to seriously consider this as a solution of the railroad problem.

It may be, however, that the practical difficulties of State ownership and administration may be avoided, and the practical advantages to all parties obtained, by a judicious system of regulation and control, leaving the title to the property still in the hands of private owners.

It is a sound promise that State control is legitimate because the railroad is a creature of the State and is performing a *quasi* public service.

But there is an implied contract with the State that the owners of the property may make a profit from their business; otherwise they would not have entered upon it and assumed obligations to the public. Therefore, while the State should, on the one hand, protect the public from extortion and oppression, it must see that, on the other hand, it does not cripple the corporation in the performance of its legitimate business, or prevent it from making a fair profit in doing this business. It is likely that, before the railroad system of the country be turned over to government ownership, a fair trial will be made of a plan that shall endeavor to secure their

reasonable rights both to the roads and to the public. And it is probable, in the process of evolution, such a plan will be more and more closely approximated to in the future work of railroad commissions and similar bodies.

But, aside from the relations which exist between the corporations and the public, there are others, of the highest importance, which pertain to the employees of the roads and their employers, and the employees and the public. So far but little attention has been given to this matter, the accepted opinion being that the employees sustain the same relations to the corporations and the public which are sustained by the employees of private parties. This, however, is not a fact. While the corporation, in accepting its charter from the State, accepted certain obligations to be performed on its part, the employee, in taking service with the corporation, also assumed an obligation to the public. The State, properly, holds the corporation to the strict performance of its legal duties, and the corporation has to rely, in many particulars, on the faithful performance of their duties by its employees, to enable it to carry out its public obligations. The people have a vital interest in the continuous and regular operation of the railroad. The performance of its public service is as much a necessity as daylight, or as has been said before, as the regular supply of water to the people of a great city. Whatever action on the part of any body of men that would imperil for a day even the water supply of this city would be universally considered a great crime against the people, and, were such an act attempted it is pretty certain that, if no present laws could reach the offenders, some would speedily be enacted for the purpose. It is preposterous to suppose that the citizens would permit the pumping engines to cease work because their attendants were at loggerheads with their superior officers. And it is evident that private grievances must not be allowed to work injury to the general public welfare.

To be sure, all private quarrels are in some degree, detrimental to the community at large, but we endure these indirect evils because we cannot cure them until we radically change human nature.

However, when men enter into public service they assume an obligation that the work they engage in shall be carried out on their part for the public benefit. In entering the public service they, by that act, promise to faithfully carry on the public business. In view of the alarming frequency of railroad strikes and the assertions by certain classes of railroad employees that they have the power to paralyze the business of the whole country at the discretion—or want of discretion—of the chief officers of a secret society, it seems important that the people generally, and railroad employees particularly, should realize that the employees of a corporation are a part of the corporation in its transactions with the public, and that the people will not long tolerate acts of the employees which cripple their business, any more readily than they do such acts when the result of official action by the corporation. The proposition to redress private wrongs by inflicting injuries on the public in hopes to goad it into active sympathy with one party to the quarrel, is so monstrous that it will not bear discussion. The sympathies of the people will generally be with the em-

ployee as against the employer, but the people will not always consent to pull the chestnuts out of the fire for other folks and get none themselves.

It is clear, that all questions of dispute between corporations and their employees should be settled without interfering with the business which the corporation has to do with the public. Both parties to such disputes should be held to a strict accountability, and it is here that the State should step in and act as arbitrator, the public being subject to no loss while the dispute is being adjusted. Although the corporations realize the power of the State to enforce its decrees, it remains that the employees shall also accept this doctrine and see that it is the province of the State to protect its citizens against all the evil acts of corporations, whether these acts be those of officers or of men.

It is too much, however, to expect that employees will voluntarily relinquish the power, which they at present exercise, of attempting to coerce their employers, by means of a "strike" which not only inflicts injury on the corporation but on the people. Positive legislation is required to control this growing evil. The first step is to educate popular opinion up to the point of holding all servants of the public to the full discharge of their public duties, and of insisting that the disputes between officers and men shall be settled without interfering with the business of the people. This conviction being established it will naturally follow that laws will be enacted making it a penal offence for an employee on a railroad to decline, or refuse, to perform his ordinary duties until he has been relieved from these under the rules of the service. At first sight this may appear arbitrary and unjust, but if the principle be kept clearly in view, that the public interests require a continuous and regular transportation service, and that the employee in accepting public service has assumed an obligation to serve the public as well as his employer, there is no difficulty in accepting the conclusion that such restrictions on the freedom of action of public servants is proper and desirable.

Nor is this a new doctrine. It is only its proposed application that is novel. It is only the practice on the high seas applied to the land. Long ago the truth was recognized that the safety of the ship and its passengers depended on the faithful discharge, during the entire voyage, by each officer and man of his particular duties. When the ship has arrived in port the grievances of the crew may be redressed by due course of law. But the passengers must not suffer or the safety of ship and cargo be imperiled by a "strike" on the high seas.

The United States Congress has enacted that "if any one or more of the crew of any American ship or vessel on the high seas," "shall endeavor to make a revolt or mutiny on board such ship or vessel," "or shall solicit, incite, or stir up any other or others of the crew to disobey or resist the lawful orders of the master," "or to refuse or neglect their proper duty on board thereof," &c., "every such person so offending shall, on conviction thereof, be punished by fine, not exceeding $1000, or by imprisonment not exceeding five years, or by both, &c.

The act of 1790 provides for the imprisonment of sailors in the merchant marine who refuse to proceed on the voyage, and the same pro-

visions have since been made applicable to men employed on fishing vessels. Engineers and pilots can only practice their vocations after they have been duly licensed, and they are held to strict accountability for the performance of their duties. They are required to make oath that they will faithfully and honestly perform all the duties required of them under act of Congress.

A pilot can not refuse to give his services to a vessel requesting them, nor can he leave a ship he has taken charge of until he has brought her to a place of safety.

Officers and men employed on steam vessels by whose negligence or inattention to their duties the life of any person may be lost, are declared guilty of manslaughter.

Our government has not hesitated to make the persons engaged in water transportation responsible to the courts for neglect of their duties. and it is only an extension of this authority to insist that the persons engaged in land transportation shall be governed by similar regulations.

It is not meant that the servants of a corporation should be liable to harsher conditions than are the servants of private employers, but from the moment they accept public employment they relinquish certain rights pertaining to the ordinary citizen. But while surrendering some privileges it is probable they would secure in their stead something more substantial. Although amenable to the government for neglect of duty they would, on the other hand, be under the protection of the government against injustice on the part of the corporation.

While the State should prevent loss to the public, by holding the men strictly to the performance of their regular work, as well as by restraining the corporation from excessive charges and other injurious acts, it must also see that the employees are treated with due consideration by their employer and, further, sustain the corporation against the unreasonable demands of its servants.

Heretofore the State has only used its authority in one direction, to partially protect the people from corporate injustice. It must soon extend its power to still further protect the people. and also extend its protection to the companies and their employees.

Working on the line of the public welfare, the State must look upon the three parties as its children and so order that one of these interests shall not suffer at the hands of the other. Practically the railroads should be considered as a branch of the public service and their employees as in the service of the government. Every person entering into the employ of the road should be sworn to discharge his duties faithfully, in accordance with the rules of the service and the laws of the United States, and that he would not decline or refuse to perform his duties until relieved under the rules of the service.

These rules, and the United States laws pertaining to his duties, would be put in his possession. They would provide that in case of disagreement between the road and its men the matter of disagreement should be referred to a government Board of Arbitration whose decision on the matter should be final. On the part of the road there would be no escape

from this decision. On their part, the men might either aquiesce or leave the service. As citizens they would have this choice.

The Board of Arbitration would be of the nature of a court and its decisions would have the sanction of judicial authority. The corporations, possibly, might object to being brought under such jurisdiction, but if the general welfare demand it, they will have to submit. The employees could safely trust the Board to decide favorably on all their just and reasonable demands.

The maintenance of all their existing organizations and brotherhoods could still be kept up, with only the restriction that the present system of "strikes" must be abandoned. All other beneficent features of labor associations and orders could be retained. All personal rights would be still theirs, except their duties as public servants would prevent them from inflicting injury on the public by a failure to perform the work they had agreed to do for the people. On the other hand faithful and competent men would be more secure in their positions than it is possible for them to be at the present time, for the Board of Arbitration would not allow their officers to discharge them without reasonable cause. The general tone of the railway service, thus taken charge of by the government as one of its own branches, would be raised, and employment in it would acquire a dignity which it does not now possess.

Since this paper was written the Governor of the State of Iowa has publicly said on this subject:

"It will not do," said the Governor, "to concede as a permanent principle in our system of government that the great arteries of commerce through which flows the very life blood of this nation may be clogged at the will of a few men with self constituted powers, because of real or fancied wrongs to members of a given organization. Already the State has taken these public thoroughfares out of the domain of mere private property, and has elevated them to the higher plane of quasi public improvements. It has assumed to and does in this and other states regulate the rate of charges for the transportation of passengers and freight thereon: determine in many instances what conveniences they shall furnish and what service they shall render the public; defines the precautions they shall take to prevent injuries to their employees, and in other ways exercises rights that can only be upheld upon the theory that these are public thoroughfares over which the State may rightfully exercise the control necessary for the protection of the public. To say to those who would in any way interfere with the free use of these ways by the public that they must keep their hands off, and to enforce that claim by penalties sufficient for the accomplishment of such purpose, is but a national extension of the same system to all classes and the exercise of a duty on the part of the State that, in the relation it has assumed to these roads, it cannot rightfully ignore."

It is not the province of this paper to outline in detail the composition of the Board of Arbitration. Undoubtedly more than one such Board would be required; probably one for each state. Acts of Congress establishing these Boards could only apply to inter-state railroads, but should

their action prove satisfactory the respective states of the Union would soon provide for similar bodies exercising jurisdiction over purely local roads.

It may be queried, if such a statute as the one contemplated herein could or would be enforced. The answer is, that its enforcement, or rather obedience to it, would depend on that principle which governs in the application of all our laws. Let the general sentiment prevail throughout the land that the public welfare demands this law, that it is in the interests of the people, that it is a necessary additional safeguard for the protection of their property—for a man's business is his available property—that it is a remedy for evils that every year threaten more and more darkly; and the American people will demand its enforcement as they demand the enforcement of laws against theft or arson. But until the people as a whole feel the necessity of such legislation, it were better not to attempt these restrictions. No such laws can be carried out effectually in the face of public apathy, or distrust, or condemnation.

However, as a practical solution, for the present, of this great industrial problem, "Who shall own the railroads?" this plan appears a reasonable means between the "let alone" policy that claims the untrammeled conduct of their business affairs by the corporations themselves, and the extreme one of State ownership. Having begun on this line, through state and inter-state commissions, it is logical and reasonable to proceed in the same direction, as herein indicated; the same end, the public weal, being the desired goal.

Aside from what may be termed the "outside public," there is a large fraction of the population immediately and personally concerned in the stability and prosperity of railroad operation. Mr. Poor estimates 1,500,000 persons as directly and indirectly employed in operating and maintaining the railroad business of the country; the number, of course, including not only the men employed in operating the roads, but those engaged in the production of railroad supplies, or in work immediately dependent on the operation of the roads. This represents a population of 7,500,000, and if to this be added his estimate of 5,000,000 persons, owners of railroad property, we have 12,500,000 people, or one-fifth of the total population, personally and deeply interested in the railroad property of the country.

It is, apparently, more for the welfare of the great mass of these people, than even for the public generally, that the State should further extend its sovereignty by a wise control of both managers and men. If this element will unite with the business men of the country in demanding protection against the destructive acts of a comparatively few individuals arrogating to themselves powers which no autocrat would dare to use, our legislators will soon see the necessity and propriety of enacting and enforcing such laws as will enable the artificial channels of commerce to flow unvexed by such restraints as are now daily threatened and too often exercised.

For the present it is too radical a step for the State to assume the complete ownership of the railroads. Possibly this ownership may in the future be the part of wisdom.

But let the movement in this direction be a careful one, and let us try for awhile a system of judicious regulation and control. Perhaps it may be unnecessary to do more than this.

And the same principle may be applied to the general subject of socialism; so that future wisdom may possibly settle upon a middle course of policy that will avoid Scylla on the one side and Charybdis on the other, allowing individual enterprise to develop and maintain the various *quasi* public interests, but protecting the welfare of the people by State control.

RAILROADS—PAST AND PROSPECTIVE.

BY J. H. SARGENT, MEMBER CIVIL ENGINEERS' CLUB OF CLEVELAND.

[Read Oct. 14, 1890.]

I have heretofore talked to you so much of my experience with railroads that the subject is a little stale. So to-night I will eliminate as much of that part of the history of railroads as possible.

The French style them "Ferro Corriel"—Iron Roads. That definition will shut out the ancient ways over which were hauled the large masses of rock that entered into the construction of the pyramids, for they had no iron about them.

I will not attempt to pry further into the past to find the origin of railways than their first introduction into England for the sole purpose of carrying coals from the mines to the nearest waterways.

I will say, however, that some kind of street railway is suggested in the ruins of Pompeii. In at least one of its exhumed streets we find two parallel channels cut or worn into the Basalt pavement; each is some four inches wide and three or four inches deep, passing through the center of a narrow street. They are of the same gauge as our standard gauge of to-day. There is no sign of rails but they suggest iron shod wheels to run in them.

It was not before their birth in these United States that the wooden sills or stringers that had for some time been used in the coal mines of England began to be plated with iron. At first these plates were of cast iron and were flanged to guide the unflanged wheels. The wooden sills were soon discarded and cast rails from four to six feet long and strengthened by the flange above and a "fishbelly" below and meeting and resting on stone blocks were substituted for them.

I began my railroad practice when the Grandfather of our present president was telling what he would do when he got into the presidential "cheer." Then the place hunter was as much of a hustler as today for they worried the poor man into his grave before he had occupied the "cheer" a month. But to drop irony and return to iron.

The rail then used in this country was a flat bar of rolled iron spiked to a maple ribbon, spiked in turn to an oak rail generally 8×9. This plate rail, however, was not introduced until about the time your speaker took his first lesson in mathematics.

To illustrate the facilities for acquiring a technical education even at that recent date, I will say that I was sent to a district school among the granite hills of New Hampshire with an old Adams arithmetic left over by a deceased uncle.

The pages of this venerable text book were about the size of fools-cap and the book was about an inch thick. The problems were placed at the top of the page and space was left below upon which to work out the "Sums."

My industrious uncle had worked the questions all out with pen and ink. My teacher, a student from Dartmouth College, teaching school winters to work his way through college, said he "would as soon have a last year's almanac as that." But book agents were not as plenty then as now and each scholar had to use what he could get. The old book, however, was a constant monitor to me and enabled me to keep at the head of my class. But let us return from raillery to rails.

About 65 years ago a little war raged between cast and wrought-iron rails. The wrought rails of the day were ingeniously rolled with fishbellies like the cast rail, to put the material where it would do the most good. They were made twelve or fifteen feet long with bearings every three feet with a fishbelly and lateral swell between each. This is a feat that the iron monger of today would hardly undertake on a large scale. Progress in iron making, however, is shown, for the patentees' stretch of imagination could then reach no farther than the practicability of making his rails as much as eighteen feet long.

Although at that day "Electric Welding" had not entered into the mo t lively imagination, he proposed to weld the rails together to avoid the jar at the joints. Objection was then made to the wrought iron that it would laminate by the "great wheels" passing over it and soon waste away. Its friends replied that the rails that had been in use twelve to fourteen years showed little sign of giving way. This we can readily believe when we learn that the power used was animal power and that the "wagons" carried less than three net tons each.

It is curious to read the arguments that those fathers of railways—the Stephensons, found it necessary to use to convince the public that wrought iron was better for rails than cast, and that the "Edge rail" with the flange on the wheel was better than the "flat rail" with a ledge or flange three inches high to keep the flat wheel from running off.

Centuries ago the flat stone bed for the wheels of common carriages to run upon was invented. And when railways proper began to be agitated a patent was taken out for spiking iron rails to these for the wheels to roll on, and the first rails of our Baltimore & Ohio road were of this character.

Ten years before I was born a Yankee namesake of mine invented the angle railed railway, like an elongated mule with the load suspended on

either side as the Spaniards to this day carry truck to market suspended in panniers from each side of a mule. By means of this animal railway all the fuel-charcoal for the city of Pueblo, Mexico, is now brought down from the mountains.

At this early period railroads were only designed for transportation of "goods" and freight. The idea of conveying passengers by rail was not thought of; passengers had to take "Foot and Walker's line," the saddle or the old fashioned stage coach or diligence.

To give you an object lesson I will say that it was not until after I was fourteen years old that it was discovered that an engine would progress by the friction of its own wheels.

Engineers expended a great deal of ingenuity to find some method to induce an engine to pull itself and load over the road: a rack and pinion, a settling pole, and finally the plan of our modern cable road was devised.

The contest between rail and water communication was quite lively seventy-five years ago, and I might say that this contest has come down to the present day. But when we realize that our magnificent 3,000-ton steamers between Chicago and Buffalo have not been able to prevent the construction and successful operation of five railways between the same points, it would seem that water has a hard road to travel.

Seventy-six years ago now a locomotive engine was receiving its finishing strokes in England, and on the 27th day of July, 1814 (the year of the reader's birth) was placed upon a coal road and drew the enormous load of thirty tons up a thirty-foot grade after it by the friction of its own wheels. Motion was communicated by means of a pinion upon the crank, driving cog-wheels upon the axles of the car and attaining the speed of four miles an hour.

However, the age of the railway and locomotive for the conveyance of passengers as well as freight may be stated at sixty years. On the 6th of October, 1829, the famous competition of locomotives of the Liverpool and Manchester Railway took place. The prize competed for was $2,500. The successful engine, Robert Stephenson's "Rocket," weighed, exclusive of tender, four and one-half tons; and its load, including the tender, was three times that or a gross load of seventeen tons.

The journey was thirty miles, and was performed at an average velocity of fifteen miles per hour and an extreme of twenty miles. The power of boodle at that early day is shown by the political hustlers rushing through a load of voters thirty miles inside of an hour.

The opening of the Liverpool and Manchester Railroad and the success of their little "Rocket" at the beginning of the third decade of the present century marks the birth of the present system of railways and started a boom in railways on both sides of the Atlantic that has gone on increasing in geometrical ratio to this day. I have been thus particular in recalling to your minds these facts with which you are doubtless all familiar that you may look upon the present situation and realize what has been accomplished in these sixty years, and see what a work you have before you to accomplish as much in the next sixty years.

The engineer that ran the first locomotive on this continent—Horace Allen—has died but recently. Who can foretell what means of transportation our youngest engineer of to-day may see when he reaches the age of ninety years?

The railroad and its machinery has advanced in parallel line with the navies of the great powers of Europe in their preparations for defense and attack. The heavier and more destructive machinery demanded of the steam engine the stronger and more indestructible the Civil Engineer must make his road.

The weight of the engine has been multiplied by ten and its speed by three. When the weight of the iron rail had reached 60 to 70 pounds—about all that could be done in that direction had been done. But more speed and more weight upon the drivers was demanded.

All that could be expected to be, had been gotten out of malleable iron, when Bessemer brought out his iron charged with a portion of carbon, being the hardest known element it was natural to look in this direction for hardness. Still there is hope of improving the rail by making some other alloy or manipulation.

At the demise of the wrought iron flat bar thirty years ago, the most sanguine failed to forecast the progress that railways have accomplished to this time. The roadbed proper improves by use and age but the superstructure must soon reach a limit of endurance.

In the direction of the motive power, carriages and operation we can yet look for much improvement. We see in our streets a little frail wheel no bigger than a man's hand and a slender wire able to rush forward two or three cars with a hundred passengers twelve miles an hour with others following in quick succession.

May we not hope that this power, whatever it is, may yet drive our trains with great speed and loads from ocean to ocean. This power. What is it? It is named electricity, a product of heat. Some man has just claimed that he can produce electricity direct from heat. But neither electricity nor heat can be seen or weighed, they are only known by their wonderful effects.

When the oxygen of our atmosphere, a real substance, devours the carbon in our coal mines, carbonic-di-oxide, a real substance is produced equal to both in weight, but heat, an invisible something or nothing, with immense power, which entering into water renders it invisible, may be made to produce electricity another something or nothing—a force running along those slender wires unseen, turns the wheels that carry the cars and their human loads through our streets.

The great powers of the universe, attraction, repulsion, gravity, heat, light, electricity, magnetism and life itself are all invisible and imponderable, but they are the real powers of the universe—all else is but death.

It is by the manipulation of these invisible powers that the coming engineer must expect to eclipse the works of his predecessors. The heat stored away in the coal mines, the power of falling water, the force of the winds and tides, can all be transformed into electricity and be made the

slave of man to go to the uttermost parts of the earth at his bidding with only a slender wire to move upon.

To the steamboat engineer I will say that I have witnessed the whole progress of steam navigation from the little "Walk in the water" to the magnificent fleet that now carries more tonnage through the "Soo" canal between Lakes Superior and Huron in a half year than the world sends through the Suez canal between the Atlantic and Indian Oceans in a twelve months.

Go on gentlemen with your creations, you may yet be able to conserve the very storms that buffet you into electricity with which to turn your wheels. Who knows? In view of the past nothing is too extravagant to anticipate.

Engineers in conclusion let me ask you to look over what the engineers and pioneers have done upon this great chain of inland seas in the central eighty years of this nineteenth century creating from the Indians' wigwam and the fur traders' hut, one city well on its way to its second million of people and three others moving on in their second quarter million and see what is left for you to do.

My prophetic vision sees the largest ships provided with unobstructed waterways from the Lakes to the Gulf and from the Gulf of Mexico to the Pacific—more than one. I see again aluminum rails diving under the Niagara, the Detroit, the St. Clair, and the Sault St. Marie river and over your cantilever bridge spanning the Straits of Mackinaw, and I see your vestibule trains rushing over unbroken rails from Hudson's Bay to the Straits of Magellan, gathering up and distributing by the way the produce of all climates, and industries of all peoples. The silver of the Rocky and Andes mountains, the gold of the Sierra Nevadas, the pearls of Mexico, the opals of Honduras, and the diamonds of Peru and Brazil.

And instead of climbing up into the snows of the Rockies, the Sierra Nevadas, and the Cordilleras, and protecting your track with frail snow sheds I see you diving through the mountains below the snows and avalanche thus at once improving your climb and your clime, your temper and your temperature.

To the chemical and metallurgical engineer I have to say we demand of you the reduction to the metallic state of aluminum, the sapphire, corundum, emery, clay, and its other abundant ores and from this wonderful metal and its alloys produce us a rail that in hardness and durability shall as far exceed the Bessemer as the Bessemer exceeds the iron. Now it is claimed that steel by a slight change in its manipulation—*cold rolling*—may be doubled in its resisting power.

These are a few of the things dreamed of to-day. But engineers there are many wonderful things not yet dreamed of in our philosophy.

By the rules of the Club, this evening is set apart to be occupied by the Mechanical Engineers. It is by the request of the Program Committee that I read my paper to-night, but in closing I wish to say to the Mechanical Engineers that their ways have felt the influence of the century as much as have the ways of the Rail Road Engineer.

Your creations have banished the sickle and the scythe, the domestic spinning wheel and loom, you have rendered the waterfall and the wind, the needle, and the tallow dip almost insignificant.

But gentlemen you have not yet "got there" as witness the thousands of new inventions taken out yearly. Our manual training schools are multiplying thinkers, and brains by use of your machines are doing the work of fingers.

I will also embrace the opportunity to say a word to the hydraulic engineer. You are about to give us a new intake for the water we drink and I wish to renew my protest against a crib, for it arrests the surface currents and floating ice until your powerful pumps can suck down the filth that accumulates there. But instead take in the water thirty feet below the surface beyond the reach of waves, winds and surface currents.

The oils and deleterious matters brought down from the rivers, rising from the bottom or floating away from the shore remain on the surface. Anything heavier than cold water sinks to the bottom before it can reach the intake.

Give us pure water and we will give you rapid transit.

Old things are being done away with and all things are becoming new.

Now that I have broken over my bounds so far I will go a little farther and say to the chemist, the metallurgist, the sanitarian, and architect, you must not rest upon your oars but give us new compounds if not simples, stronger, and more indestructible material, and more healthful and beautiful homes.

DISCUSSION.

The discussion following the reading of the paper was substantially as follows:

* * * * * * * * *

MR. HERMAN:—Mr. Sargent's paper reminds me of a little experience I had about thirty years ago on a railroad running from the City of Prague into the Coal Districts. We started about five o'clock in the morning. Directly after starting we ran over several hundred feet of twenty-five pound rail, and then got on a flat rail. Afterward we got on a cast-iron rail. These cast iron rails were wonderful to see; mostly broken. Very often a piece of the rail would be missing. In such an event the driver would go back and find a piece to fill the gap. When we got within about three miles of the destination a down-grade began, and here the driver detached his horses and the cars were allowed to make the balance of the journey alone.

MR. BOWLER:—Referring to the "Jersey State Road;" stone was used for ties. As to the rails I am not sure that they were cast rails; but the first cast rails used were according to Mr. Sargent's description. They had a flange on the side and were four feet in length. In 1845 and 1846 there were plenty of stones that had been used for ties lying on the side of the road, being useless, wooden ties having begun to come into use.

MR. BARBOR:—About a week ago I was stopping for a short time in Denver and on the way there stopped at St. Louis and Kansas City, and availed myself of the opportunity to ride upon the different street railroads: and when I reached Denver I found the cable cars and took pains to ascertain from every source at my command the relative popularity of the two systems, the electric and the cable. In every case I was informed that the electric road was the more popular. I visited the Denver Traction Company's power house and while there, in talking with the man in charge, he indicated to me that he thought the time was coming—and very shortly too—when they would change from cable to electric power. In fact they had one line then. I could not, of course, help noticing the difference when riding first on one and then on the other—the difference in the movement of the cars, especially in Kansas City where they go up and down a hill repeatedly. The movement is much more jerky and rather unpleasant on the cable roads, especially in going around curves. I understand that if the driver loses his grip upon the curves it will be difficult to catch the cable again.

MR. ROBERTS:—I am not a railroad engineer; nevertheless I may say that in the operation of electric railways there are two problems: one is rapid transit, almost irrespective of cost, and the other is for a long distance passenger traffic.

The idea has been worked out by Mr. Sprague, presumably within fair limits, of the probable cost of an electric road between New York and Philadelphia. He shows that it would be financially possible to build a road between Philadelphia and New York, with a station for generating power at New York. I think one at Trenton and New Brunswick, and the other at Philadelphia, about four stations on the line—it is to be used entirely for passenger traffic. Mr. Sprague states that he considers it could enter competition with ordinary steam railroads, but probably it would be advisable to charge more for the trip in consequence of the faster time to be made. That would be rapid transit irrespective of cost, and a good many men would pay to save an hour.

In regard to supplanting ordinary steam railroads for long distances, Mr. Bailey read an interesting paper on that subject about a year ago, showing, as nearly as could be figured out, the cost of furnishing electric power would be about the same under exactly the same conditions as the road referred to as in furnishing steam power.

Mr. Crosby has worked out the problem quite thoroughly and shows according to his figures, presuming all mechanical difficulties overcome, that he could get a speed of one hundred miles per hour: in limits of probably twenty-five horse power, and that according to this electricity would be more economical than steam power.

In connection with the elevated roads, they have been looking forward to the discontinuance of steam in favor of electrical power. The Thompson-Houston Company are putting in a system on Ninth avenue, using large locomotives and hauling the same train units of five cars that the elevated roads do now.

The elevated road also comes into competition with the cable road. I think for short distances the cable road is financially more successful; for long distances, where there are many short curves, the electric road is ahead. The electric roads can climb a fair grade, but not so heavy a grade as the cable can do.

MR. GOBEILLE:—Mr. Fred. Scheffler, now General Superintendent of the Westinghouse Engine Company, has made a rather elaborate report to show that electricity, as applied to the ordinary traffic of railroads, as we understand railroads now, would not be practicable. This was opposed by a good many electrical engineers, of course, but Mr. Scheffler thinks he can demonstrate it.

PROFESSOR HOWE:—At what rate of speed do you understand cars will be run between New York and Philadelphia?

MR. ROBERTS:—I am informed that it will require but thirty-five minutes to make the trip.

MR. PORTER:—The New York elevated roads have investigated the subject of rapid transit thoroughly.

I believe the same parties that put in the first electric road in Cleveland also put in an electrical plant for experimental purposes on the elevated roads. After experimenting for some time they gave it up, it either being impracticable or else so expensive that the idea could not be carried out. I understand that several times since then the elevated roads have made other experiments on the same subject. This summer, as I understand, they have carried on a more elaborate series of experiments than at any other time. The report of an expert has shown that it will not, for the present, be practicable to use electricity on the elevated roads in New York unless great improvements are made. It, I understand, can be done, but not economically. Possibly the expense may be reduced by using cheaper grades of coal, etc., but at present, with the cars they have, and the traffic, they could not advantageously use electricity.

Mr. ROBERTS:—In Boston they have put up a structure especially adapted for an electric road, after having abandoned the other; and they have the advantage of putting in a lighter structure than they would have put up for a steam road to carry the same traffic. Even if it costs a little more for power it would be for their advantage. They could not put up a steam road now on account of the noise, etc., whereas they have overcome whatever objections there were to electric roads.

I understand that it is intended to put in a road in the South seventy-five miles in length, from which we may be able to get a great many financial facts, as well as other interesting data.

PROFESSOR HOWE:—I want to speak about a steam street railway system that is being experimented with in the city now. The inventor of this system proposes to take his steam in every half-mile, and the car would travel until it reached the next station. It would be taken in while the car was in motion. A system of valves are arranged at the level of the street, and as the car goes over them, at a slow rate of speed, it presses down these valves and opens them, and the tank is filled with steam in

about three seconds with enough to carry it another half-mile. Nothing has been done in a practical way yet, except to show that steam can be taken into the boiler.

MR. SARGENT:—About twenty years ago, when in New Orleans, I rode on a road of about three or four miles in length constructed on this plan, except that at each end of the road they forced in steam at a very high pressure, and carried nothing but the boiler; and steam enough was gotten in to propel the car three miles.

MR. PORTER:—In 1884 I took a ride on this road. They do not really use a fireless locomotive. They fill the boiler with steam and do not pretend to do any firing, except enough to prevent the steam from condensing.

THE MUIR GLACIER IN ALASKA.

BY PROF. H. F. REID, PH. D., OF THE CASE SCHOOL OF APPLIED SCIENCE, CLEVELAND, OHIO.

[Abstract of some remarks made before the Civil Engineer's Club of Cleveland, O., November 11, 1890.]

A party, consisting of Messrs. H. P. Cushing, H. M. McBride, R. L. Casement, C. A. Adams, J. F. Morse, and Harry F. Reid, passed last summer encamped at the mouth of Muir Glacier, Alaska, for the purpose of studying and exploring the glacier.

The mouth of the Muir Glacier is situated in latitude 58° 50′ N., and longitude about 136° W. of Greenwich. It lies among the mountains near the southern end of the great St. Elias range, and drains an area of about a thousand square miles. The snow which falls on this area is compressed into ice, and moves down like a river into an inlet of Glacier Bay. Here the glacier ends in a great ice wall a mile and a half broad, and in places rising up more than two hundred feet vertically from the waters' edge. From this ice front great masses of ice continually break off with a loud report and float away as icebergs. We saw some, three or four hundred feet long, standing seventy or eighty feet out of the water, though usually, in the act of falling, the larger masses break up into smaller pieces.

Captain Carroll, of the steamship "Queen," has sounded a depth of seven hundred and twenty feet just in front of this ice wall; the ice, which undoubtedly reaches the bottom, must therefore be nearly a thousand feet thick in the middle.

Our first work was to make a survey of the glacier in order to determine its size, the breadth and height of the ice front, the distance and height of the surrounding mountains, etc. Our instruments were supplied by the U. S. Coast and Geodetic Survey. We measured off a base

line nearly two-thirds of a mile long on the west side of the inlet, and by triangulation established the positions of a number of prominent points. To these points we carried our plane-table and mapped in the neighboring mountains: fixing, at the same time, the positions of more distant points, to which the plane-table was then taken and the work continued. The mountains in the immediate neighborhood of Muir Glacier are not very high (only from six to seven thousand feet) but on account of their high latitude, and the large annual snow fall, they have all the appearance and characteristics of mountains of twice their altitude in the Swiss Alps. About fifty miles to the west tower the Fairweather group with at least two peaks over fifteen thousand feet high.

The motion of the ice interested us particularly. An expedition, which visited this glacier four years ago, reported that the motion was from sixty to seventy feet a day. The glacier, near the front, is broken up by deep crevasses into innumerable ridges and pinnacles of ice. It was by observing the position of certain pinnacles, at intervals of several days, that the above result was obtained. All observations on other glaciers have shown motions much slower than this. The Mer de Glace, in Switzerland, moves but three feet a day. Fearing that an error might have arisen by mistaking one pinnacle for another, we determined to make strenuous efforts to force a way across the glacier and plant in the ice a set of black and red flags, whose positions could be accurately determined by our two transits, one placed on each side of the glacier. We were provided with ice-axes, such as are used by climbers in the Alps; and wherever there was any danger of an accident we were fastened together by a rope, so that if one slipped the others could hold him. We made trial after trial, now from the east side, now from the west side, of the glacier; and finally succeeded in setting out a satisfactory row of flags, though a short distance in the middle of the glacier defied all our efforts to cross it. The observations on the flags showed a motion of from eight to ten feet a day in the most rapidly moving portion of the ice. The great care we took to avoid all sources of error leaves no doubt that this result is substantially correct.

Muir Glacier shows many evidences that it is undergoing great changes. It is the objective point of excursions which take place every summer from Puget Sound. The captains of the steamers, who have visited it for several years, claim that they notice a recession of the ice front of a mile or more. Though probably true, this is somewhat indefinite, for they took no means to determine its position from time to time. We mapped in the ice front and fixed its position with respect to two cairns of stones which we made. If, in a few years from now, some one will again fix its position with respect to these same cairns, the rate of recession can be accurately calculated.

The moraines of Muir Glacier exhibit peculiarities which have not been observed elsewhere. About twelve miles back from the front of the ice is a broad valley, which forms a second outlet to the glacier. The glacier runs four or five miles down this valley, and ends in a second ice-

wall in a lake. A large moraine can be traced from the top of this ice-wal back over the glacier and down to the main ice front, without anywhere approaching the mountain side. A moraine with two ends and no apparent beginning is rather a puzzling phenomenon.

We made magnetic demonstrations, and also regular meteorogical observations for about two months. The weather last summer was unusually fine for Alaska. However, one can hardly, with reason, complain of the bad weather when it does come, for it is to the large amount of precipitation that we owe the existence of the glaciers and the grand scenery of this region.

THE EVOLUTION OF THE ELEVATOR.

By Robert M. Sheridan, Member Engineers' Club of Kansas City.

[Read May 12, 1890.]

The business of building elevators is an "Infant industry." Within the memory of those who are still engaged in its pursuit it had its birth.

Our immediate ancestors walked up-stairs and raised packages of freight to their lofts by means of a single sheave arrangement over which a hempen rope was laid, one end being fastened to the freight, the other to an ordinary winch. The year 1855 witnessed the first efforts to economize manual energy, in this direction, by using steam as a direct agent to perform the work of raising and lowering a platform upon which freight was placed. The method of this application was complicated and very roundabout. The engine consumed steam to the equivalent of twenty horse power of energy [illegible] expended it in the lifting of less than one-third that power. [illegible] some freak of engineering, it was thought the proper thing to over-counterweight the platform so that the counterpoise equalled the weight of the platform plus the frictional resistance of the load rising, and in excess of such requirements there was allowed about an additional one-fifth in weight to help the engine to raise the load. This caused the platform to rise in a way that must have given pride to the constructor; but it was a good thing in one direction only, because it necessitated the extra and purely unnecessary work of pulling the platform down.

There are still a number of these machines in more or less active service in the warehouses in New York and Boston, and occasionally one may be stumbled upon as far west as the Indiana line. During the period embraced by the years 1855 to the close of the war no material permanent improvements were made in hoisting-engines of this class. In this, as in almost everything else, the parent necessity begot the child invention. The development of the older cities produced the need for higher build-

ings, and rapidly following such innovations the "evolution of the elevator" became more and more marked. Passing from change to change, improvements and blunders closely followed one another. The warehouseman and the merchant demanded more economical handling of the machines which had grown to become so essential to the proper conduct of their steadily increasing trade. About this time men found it convenient to be carried to their destinations, and were pleased with the conservation of energy made possible by the avoidance of long and tiresome stairways.

The user of the first elevator for distinctively passenger purposes is unknown. I have heard it stated that he was the laziest man in his day. But "tall oaks from little acorns grow," and to-day we are a nation of "lazy men" if the disinclination to climb ladder-like stairways proves anything. This is man's evolution. Had he been destined to climb stairs, nature would have provided for the emergency by putting a third joint in the legs or by doubling the capacity of the gastronemius muscle.

It was about 1870 when the first regular steam passenger elevator was produced. It consisted of a double reversing engine, with the cylinders oscillating, the piston rods driving a pulley from which a belt conveyed power to the axle. At the end of this a pinion intermeshed with a moulded spur gear upon the periphery of a drum. Over this drum, in turned grooves, the cables were wound, conveying the motion to the car. The movement of this car was pulsatory, owing to the spur gearing.

This was a great step forward, bounding at once with all the embryonic elements of success; except in the smoother running of the car. The last was easier of accomplishment.

Now the same engine is used, excepting that the cylinders are stationary. The belt is dispensed with and the power communicated to the drum by the contact of a phosphor-bronze gear wheel, the teeth of which are cut to an Epicycloidal curve.

This is driven by a cut-steel worm fixed upon the crank shaft, converting the reciprocating motion into a circular one. The drum is made of sufficiently large diameter to admit of considerable speed upon the car without increasing the engine's piston speed beyond an economical point.

The development of this engine worked an important stage in the manufacture of passenger elevators. The first-named engine with the spur-geared combination is now the standard steam freight elevator. The last one is now being used with unvarying success both in economy of operation and smoothness of motion, and is the perfected steam passenger elevator, rivaling the hydraulic for large plants, and often excelling it in economy where only one elevator is required.

I have outlined the development of the steam elevator engine up to its present condition. At various times during twenty years experiments of many kinds, tending toward the use of water as a power for elevator service, have been made. It is only within the last ten that success sufficient to justify the general introduction of the hydraulic elevator has been met with. The first decided step in this direction brought forth an ele-

vator operated by the water pressure conveyed to the top of a piston placed vertically within its cylinder. Sheaves, around which the lifting cables were turned, were attached to the top of this piston, and by placing the cable around a similar sheave at the top of the building the falling of the piston distended the cables and raised the car to which they were anchored. Descending, the weight of the car raised the piston after the valve was opened to free the water resting upon it, and this water, passing through an opening at the cylinder's top, was conveyed by a small pipe placed parallel to it into the same cylinder at its bottom, thus forming a resisting force to prevent the piston's falling when the movement of the car was arrested.

Contemporaneous with this form of hydraulic engine, the horizontal cylinder was developed. In this machine the cylinder is horizontally placed in the lowest part of the building, and the water pressure being taken where it is naturally the greatest, operates directly upon the piston, moving it in the forward direction. At the forward end of the piston a cross-head carries the sheaves, and at the rear or closed end a cross-head, anchored to the cylinder, carries a like number of sheaves. The cables, passing over these, beginning with the anchor upon the rear flange of the cylinder, are distended by the water, forcing the piston forward. By this means the car is lifted. To lower it the water is allowed to pass out through the exhaust part of the valve, and when the car's descent is checked the piston is blocked by the solid body of water against it. The stroke of the piston varies with the car's travel, being proportioned 6 to 1, 8 to 1, 10 to 1 or 12 to 1, depending upon the various conditions affecting each particular case.

Without presenting drawings, it is not possible to give a tangible description of the valve movement which renders it possible to start and stop the car rapidly without producing undue strain upon the machine, or communicating an unpleasant and dangerous motion to the car.

With the use of a stationary lever, fixed in a panel within the moving car, the hydraulic passenger elevator of to-day gives a service adapted to the needs of the tower-like buildings which are to be found in the large cities. Without some such an arrangement it is not possible to supply the rapid and safe service which such buildings absolutely require.

The valve of the old type in use upon hydraulic passenger elevators consisted of a plunger, which was operated by the direct pull of the rope within the car. This pull, being communicated to the valve by means of a small pinion working upon a rack, permitted the full working pressure to be brought against the piston within the elevator cylinder. The starting of the car was thus made abrupt and unpleasant, and the stopping equally so. To overcome this serious objection was the object of several years' experiment.

It remained for an outsider to discover and patent the vital principle of an auxilliary or pilot valve, which, being first operated upon by the motion given by the lever within the car, allowed the working pressure to

gradually force the main piston, uncovering a series of graduated openings through which the water was admitted to the elevator cylinder. A Mr. Risdon, of San Francisco, experimenting during the year 1882, upon a valve for controlling the operation of some machinery for the manufacture of sugar, first made use of the auxilliary valve in connection with the controlling of a main piston valve of the type mentioned. A somewhat similar pilot valve has been used for some time in the mechanism employed for the steam steering of vessels.

The question of safety has played a very important part in the development of elevator machinery. In a properly designed machine all other features are subordinated to the desire to obtain absolute safety under all possible conditions. To this end various safety devices have been tested. Such experiments have resulted in the adoption by the more prominent elevator makers of the principle of the centrifugal governor attached to the car. This arrests the car's motion when it travels beyond a safe speed and has proved to be the best device for arresting the car in the hatchway in the event of the cables breaking.

The most prolific source of accident to elevators has been caused by the car becoming ungovernable through the breaking of the operating cables or its connections. To obviate such a difficulty an independent automatic stop valve is placed between the operating valve and the cylinder. The water, in passing in and out of the cylinder, is compelled to pass through this valve. The movement of the elevator piston, at its terminals, closes this valve, so that when the car has reached the top floor the piston has automatically encountered and closed the valve, thus preventing the further rise of the car by cutting off the water supply. In descending the same encounter takes place when the car is within a few feet of the lowest landing. The exit of the water is in this way prevented, and the car safely and gradually stopped. It follows, from the use of this valve, that at the terminal landings of each trip the movement of the independent automatic stop valve safely arrests the car's movement without the interposition of the change valve or any interference from within the car.

It has been by the aid of such carefully designed devices that accidents to properly built elevators have been so rare. Indeed, the proportion of accidents to the number of elevators in use is insignificantly small. Although there are no available statistics to cite in confirmation of this claim, yet the statement will be accepted for want of any contradictory information.

In summarizing the condition of the elevator in the present stage of its evolution, it is not necessary to point out the many advantages resulting from its use. Its development has permitted the architects of our own time to erect Babel-like structures, the necessity for which is growing greater each day. In the larger cities, upon all sides, we are confronted by structures rising in many instances to the height of fifteen and sixteen stories. Such buildings demand elevator service of the most advanced type. Speed, therefore, has become the great desideratum. Taking one

of the most prominent examples, to show the high rate of speed at which passenger elevators are compelled to travel, the inestimable value of the safety features I have touched upon becomes easily apparent. The passenger elevators supplying the service to the offices in the tower of the Chicago Auditorium building travel through a distance of two hundred and twenty feet at a speed of six hundred feet per minute, or about *seven miles per hour*. The requirements for the ordinary buildings compel a speed of from 300 to 450 feet per minute.

It is not difficult to surmise what will be the requirements of this nature within the next few years. There is no evident sign of the intention of our Architects to restrict themselves in the height of their future buildings to "anything under the sun," and unless some "confusion of tongues" shall come upon them, we may find them emulating the example of those who built the first "tower" of which we have any definite knowledge.

It is certain that the requirements for elevator service in the future will be somewhat exacting.

In the past those engaged in the manufacture of this class of machinery have kept fully abreast of the constantly changing conditions; and in the future there is every reason to believe that the elevator's evolution, still going on, will follow closely the necessities of the demands which created it.

ASSOCIATION OF ENGINEERING SOCIETIES.

PROCEEDINGS.

WESTERN SOCIETY OF ENGINEERS.

The 274th meeting of the Society was held at its rooms, Wednesday evening, November 5, 1890, at 8 o'clock p. m., President L. E. Cooley in the chair and over 40 members and visitors present.

The minutes of the October meeting were approved, and the Secretary gave a report of the meeting of the Board of Directors.

The following gentlemen were elected: Samuel B. Stickney, Alva Philbrick, Wm. Gerig, Robt. E. Williams, Chas. H. Swigart, Arndt L. Hammerberg, Noah Whitley, Wm. T. Blunt, Wm. M. Rees, Chas. D. Marx, Wm. Powrie, C. B. Stewart, Onward Bates, Percy H. Richardson, Chas. W. Stewart. Victor Hagmann, (October.)

The following applications were placed on file: Bertrand E. Grant, Henry W. Tuttle, Geo. B. Springer, Albert L. Eliel.

In reply to a call for reports of committees, the Secretary presented the following report of the convention of delegates from various societies, which met in the rooms of the Society on October 14, 15, to discuss the question of the establishment of Engineering headquarters and the holding of an International Engineering Congress in 1893.

REPORT.

The convention met at 10 a. m. in the rooms of the Western Society of Engineers, 78 La Salle street, Chicago, Tuesday, October 14, 1890. The Societies represented and the delegates present were as follows:

The American Society of Civil Engineers: Wm. P. Shinn, (president) C. L. Strobel, A. E. Hunt. The American Society of Mechanical Engineers: Wm. Forsyth, Jesse M. Smith. The American Institute of Mining Engineers: Wm. P. Shinn, A. E. Hunt. Canadian Society of Civil Engineers: J. D. Barnett, O. Chanute. The American Institute of Electrical Engineers: E. M. Izard. The Engineers Club of Philadelphia: H. W. Spangler, Wilfred T. Lewis, E. V. d'Invilliers. The Civil Engineers's Club of St. Louis: J. B. Johnson, E. D. Meier, Robert E. McMath. Civil Engineers' Club of St. Paul: L. W. Rundlett, W. W. Curtis, S. D. Mason. Wisconsin Electric Club: Warren S. Johnson. Engineering Association of the Southwest: E. L. Corthell. Civil Engineers' Club of Cleveland: Wm. T. Blunt, John Eisenmann. Engineers' Club of Minneapolis: Wm. A. Pike, F. W. Cappelen. The Society of Civil Engineers, Paris France: E. L. Corthell. The Engineers' Club of Western Pennsylvania: A. E. Hunt. The Western Society of Engineers: O. Chanute, D. J. Whittemore, E. L. Corthell, C. L. Strobel.

Mr. E. L. Corthell explained the object of the meeting and letters were read by the Secretary from Col. Geo. R. Davis, Director-General of the World's Columbian Exposition, and the Hon. Benj. Butterworth, the Secretary, both warmly seconding the proposed Congress, and promising all proper aid.

After organization and discussion a committee was appointed to formulate a plan and to report to the Convention, which adjourned to meet again next morning:

OCTOBER 15. The following report was submitted.

CHICAGO, Ill., Oct. 15, 1890.

To the Chairman of the Convention of Delegates from Engineering Societies of the United States and Canada:

DEAR SIR:

Your committee on plan for establishing and maintaining a joint Engineering

Headquarters in Chicago in 1893, during the World's Columbian Exposition, and for holding an International Engineering Congress at some time during the Exposition, beg leave to report:

It finds itself unable to present at this time more than a brief outline plan.

The proposition advanced by the Committee of the Western Society of Engineers to this convention yesterday embodies our views, with some changes which we have made in the plan herewith submitted.

First. ENGINEERING HEADQUARTERS.

In view of the existence in this country of several large Engineering Societies of high rank which will desire the use of headquarters for their own members, and for the entertainment of foreign visitors, and the inconvenience and expense which would result from the maintenance of separate establishments, we think it very desirable that all the Engineering Societies of recognized standing in the United States and Canada be requested to unite in establishing and maintaining a joint Engineering Headquarters during the continuance of the Exposition.

The Exposition management will probably furnish space free of charge within the Exposition buildings, but it may be deemed advisable to provide additional quarters outside; the headquarters to be a rendezvous for all the members of the Engineering societies of this country, and their use to be freely tendered to all foreign Engineers.

It is expected that the staff shall consist of a joint Secretary and two or more assistants, some of whom shall speak the principal European languages. The staff to be charged more especially with:

(*a*). To give information concerning the location of various engineering exhibits within the Exposition,

(*b*). To give visiting and foreign engineers information about points of engineering interest, outside of the Exposition, and to aid their investigations in other ways.

(*c*). To give visiting and foreign engineers introduction to those whom they may desire to meet, and to promote social intercourse.

(*d*). To keep a record of the addresses of visitors and to invite them to the International Engineering Congress hereinafter outlined.

It is estimated that the expense will amount to about $10,000. This it is suggested may be met by an assessment of one dollar per member of each Engineering Society of this country which shall join this proposed association, and also by voluntary contributions. The details to be hereafter adjusted.

It is evident that this plan will be far more economical than that of maintaining separate headquarters by the several societies.

Second. ENGINEERING CONGRESS.

At some time to be hereafter designated during the Columbian Exposition, it is proposed to hold within the Exposition, in a building which the management thereof proposes to furnish, an International Engineering Congress open to engineers of all nations. This Congress to last six days and be conducted in the English language.

The opening session of welcome and organization to be a joint session, and if warranted by the attendance and the number of papers offered, the Congress then to be divided into sections to consider and discuss the various branches of Civil, Mechanical, Mining, Metallurgical, Electrical, Military and Naval Engineering.

A Chairman and Secretary for each section to be designated in advance, and the session to be so timed that papers and discussions on allied subjects shall not occur simultaneously so as to preclude those interested from attending several sections.

The Congress to terminate with another joint session.

All papers, so far as practicable, to be furnished in advance, to be carefully examined by the proper committees under rules to be hereafter laid down, and if found acceptable, to be printed for distribution in advance to the members of the

Congress, at which they are to be chiefly read by title so as to admit of immediate discussion.

Intending contributors to be requested to confine their papers, so far as possible to such new and recent constructions, machines, processes, methods, experiments and investigations, including proposed standards of test and measurement as are of engineering importance. Papers on purely speculative subjects should not be received.

A small fee say ($2.00) to be paid by members attending the Congress, to defray expenses. The papers and discussions to be subsequently printed and furnished to such members as may so request at a stipulated price.

A Permanent Committee to be chosen in advance, to organize the above proposed Headquarters and Congress.

Respectfully submitted: E. L. Corthell, O. Chanute, Jesse M. Smith, D. J. Whittemore, C. L. Strobel, W. W. Curtis, J. B. Johnson.

The report was unanimously adopted in the following resolution:

Resolved, That the report of the committee on an International Congress and joint Headquarters be accepted, and that we report the same to our respective societies, with the recommendation that action in approval or in disapproval of the same be taken within the next two months, and that we desire the present committee to be continued with power to carry on the correspondence and organization until its successor is appointed.

In furtherance of the plan adopted the following resolution was passed by the convention:

Resolved, That it is the sense of this convention that the general permanent committee on International Congress and Engineering Headquarters be composed of one member from each of the Societies which shall join in the plan, except that the American Society of Civil Engineers, the American Society of Mechanical Engineers, the American Institute of Mining Engineers, the American Institute of Electrical Engineers and the Canadian Society of Civil Engineers, may each appoint two members, and the Western Society of Engineers may appoint three members of such committee.

The following resolutions were also passed:

Resolved, That the Secretary be instructed to prepare minutes of the proceedings of this convention and the resolutions adopted, and that he, as soon as possible, have the same printed and sent to each delegate, and the Secretary of each of the Societies represented.

That the Executive Committee of the Convention be empowered to call the first meeting of the delegates, provided for in the resolution adopted, at such time as they may see proper after January 1, 1891.

John W. Weston, Secretary.

In connection with the above report the Secretary presented the following resolution from Mr. Corthell, which was accompanied by a brief explanation of what the Committee had done and the success which so far had attended its efforts in every direction in which it had moved, and requested that the committee be discharged.

"Resolved that this Society approves the favorable action of the Convention of delegates from the National and Local Engineering Societies of the United States and Canada, held in this city on the 14th and 15th of October last, to consider the proposition to establish a joint Engineering Headquarters and to hold an International Engineering Congress, and requests the President to appoint without delay a Committee of three to represent this Society on the General Committee, the appointment of which was recommended by the Convention."

The motion was seconded and unanimously adopted.

In regard to the appointment of a permanent committee the President would take time to consider the question, but he was under the impression that the Society could leave the matter for the present in the hands of the old Committee.

The amendments to the Articles of the Association of Engineering Societies, printed in the September proceedings were then brought up for action.

Mr. L. P. Morehouse stated, as a member of the Board of Managers, that these

questions were very seriously considered by the Board and it was thought very proper that the Societies should adopt them. He did not know of any reason why the Societies should not unanimously adopt the amendments.

The amendments were put to vote and unanimously adopted.

Motions were then made for the appointment of the usual annual Committees to report at the December meeting: "On Nomination of Officers for 1891" and "On Annual Meeting and Entertaiment."

The President named the following on Nomination Committee: Messrs. Corthell, Gottlieb and Artingstall.

On Annual Meeting: Messrs. Lundie, Karner and Alexander.

The paper of the evening, "The State and the Railroads," being now in order, the author, Mr. L. P. Morehouse, said:

I am aware that the paper which I am about to read is not properly one to bring before a Society of this kind, as it is not a professional paper, but I was informed that no professinal paper had been offered for this evening, and was asked to read this one. On some occasions in the history of the Society, similar papers have been presented, and so it is not entirely a breach of custom or usage. On reading it over I made up my mind that it might conform in one particular to a professional paper, in the fact that it was, I thought, about as dry as anything that ever came before the Society. If you look at it in the right light, you may consider it professional. Perhaps it will be necessary for me to say that I use the term "State" in its broadest sense, as representing the people—not the State of Illinois or State of Iowa.

The paper dealt with the relations between the people and the railroads, the railroad officers and the employees, and railroad employees and the people. It will be found in this issue of the JOURNAL.

In calling for a discussion the President remarked upon the interesting matter presented, containing much food for thought.

MR. A. C HARDING:—The gentleman did not speak on one or two matters that have been forced on my mind, particularly the border ground upon which our State control of Railroads rests; that is the interest of the public. I do not think he went into that as fully as it warrants. The State control of Railroads and of private property does not rest, in my mind, on a simple contract between the Railroad and the State, or act of the Legislature. When a man invests his money in damming a stream, and building a mill for the purpose of grinding his own grist, he has invested his money in an enterprise to which everybody in the neighborhood,—by a law that is older than any law we know of,—has a right to come and leave his grist to be ground, and the rate he shall charge, or the fractional part of the bushel he shall deduct has been fixed for a couple of thousand years, and it is that principle which underlies the State control of Railroads—the right of the public.

MR. MOREHOUSE:—My impression is that the State Board of New York made no report in the matter of the New York Central strike and undertook no action. Had the Board made a report it would simply have been an extra judicial expression of opinion, as that Board has no authority to enforce its decrees in such a matter is simply a friendly Board to act in such cases between the corporation and the men, but it cannot enforce its holdings or its decisions.

There is no law in any State, I think I am safe in saying, that will oblige a corporation to accept the decision of the Board as between employers and employees, and there is certainly nothing obliging the employees to do so. The men can only be obliged to respect such a decision by the enactment of specific laws for that particular purpose, binding the employee, when he enters the service of the Company to observe these laws or be subject to a penalty. There is no power in the United States now that can inflict a penalty upon an engineer or brakeman who deserts his train twenty miles away from a station, with a load of passengers.

MR. BOURLAND:—It strikes me that there could be no law formulated which could take in hand in any way a strike that was proceeded with in the nature of that New York Central strike, where the men simply walked out, and took no antagonistic position. When the C. B. & Q. men struck, it was held that they were obliged to do their work, but when every other excuse gave out, they were sick and no man could gainsay that.

PRESIDENT:—The theory is that the employment is in the nature of any other employment, whereas as a matter of fact, it is a public service, very much as though a man entered the army. It seems to me all it wants is a few court decisions. The propriety of it is so obvious that it could be reached directly in the courts.

MR. RANDOLPH:—The President suggests that it only needs a few court decisions to decide this thing. On what law should these decisions be based?

PRESIDENT:—The common law of public safety; the general idea that if the employees of the Chicago Gas Works should stop to-night and this city be in darkness; —it seems to me that there should be a law that such a thing could not happen. The idea that I throw out is simply a crude one on that question.

SECRETARY:—It has always appeared to me that a leading cause of the continual differences between the Railroads and the people is, general lack of training, speaking broadly, of the railway officials. It seems to me impossible to supply railroad officers, thoroughly qualified, to meet the demand of our enormous yearly mileage construction. The people naturally expect that their rights shall be at least respected, and the questions involved are as important as they are delicate, requiring a high order of intelligence. I believe that statistics would show that the large majority of railroad officers are taken from the ranks and most of us, from personal experience, would scarcely consider the field a promising one from which to select men equal to the high order of work demanded under the present relations between the corporations and the public.

MR. MOREHOUSE:—I do not think that at this time it would be desirable for the Government to own and operate all the roads of the country, but it does seem to me, that in the course of, I don't know how many years, whether twenty or fifty years—events come along so very rapidly in these days,—in the course of time, we will say, and no very distant time, the Government may own all roads, but as I have suggested to-night in this paper, it is quite possible that instead of coming to that, a judicious system of control may answer all purposes and be really more satisfactory to the people, and be accepted by the people more readily than State ownership would be. I am a little inclined to that opinion, that the future will develop a policy of that sort, and that while at the present time we do not see anything between State ownership and letting the roads do a good deal a they want to, yet a judicial system of regulation and control may likely accomplish all that is necessary for the public, the owners of the roads and the employees, all three parties being intimately and independently interested in the matter. So many practical difficulties arise at once when one considers the immediate acquisition of the roads by the State.

Of course our Government might pursue the policy enacted abroad with future roads, but you have your existing roads, which constitute the knotty problem. A very strong argument against the Government owning the roads is the question of politics. You have to estimate that element in some way before you can consider the matter seriously, and we cannot eliminate it at present. I say it is one of the practical difficulties that we are met with.

PRESIDENT:—There was a time, in the history of this country, when they even attempted to charter our rivers, and it was in 1807 that it was first determined that a river was public property. Harbor and port dues come down to a very recent day. Now the tendency is for all harbors to become free. We know the situation as regards water works. Sewerage, of course we all know about; gas works, street lighting, is to a certain extent in this city, and I believe will ultimately be everywhere, as much as water works, under control of the city, and I expect to see the time when no city in the State of Illinois will be allowed to give a franchise of any kind whatever. It is a question I think that raises itself in every man's mind. For instance in regard to water works in the City of Chicago. We will suppose that it costs from 4 to 11 per cent. to collect a revenue from it, and you can collect it from the Gas Co. for 1½ per cent., which is pretty nearly a matter of fact. But here is the idea. We have sunk a capital account in the Chicago Water Works to-day, paying operating expenses, but at the same time, if it were a private corporation perhaps we would be paying the interest on the immense outlay; and it is a question whether we cannot afford a little loose management in a thing of this kind rather than to pay interest on a capital account which increases and grows rather than decreases; so I do not know that the political argument in connection with a matter of

that kind is a serious one. We like to pass burglar proof laws, and then elect men to office, armed with a "jimmy," let them break them open, and then admire their feats afterwards.

The idea which I have heard very strongly advanced in this State, from a considerable contact with our legislative body, in regard to the railroads is something of this nature: The railway is a highway, just as much as this street which runs by this building. The public interest in it is the same as in this streeet. There is no difference except this: If I had built this street for the public—the public allows me to retain a mortgage on that street and to hold possession of it until I pay my mortgage off. Now, on that theory, you can confiscate all the railroads that are in the State of Illinois by paying the face of the mortgage. The question arises, how are you going to get at it, provided you want to make public ownership. This way has been suggested: that it would be possible in the same way as the public works have been paid for from time immemorial, in the issue of bonds,—bonds that pay themselves out in 20 or 50 years, in equal annual installments. When a State regulates a railway charge, as it is admitted that it has the power to regulate,—if it can be determined as to what its proper capital account is, it shall be allowed to charge enough to sink these annuity bonds; or you can hypothecate the whole value of the road, stock, bonds and all at some valuation. When they are paid out, it belongs to the State. You sink the capital account once for all. Then the grand question would come up, who is to operate them, and how are they to be managed? That idea is drifting around in many forms in the State of Illinois. I simply throw it out as a suggestion, and it struck me with very much greater force in view of the suggestions to which Mr. Morehouse alludes, of Mr. Blackstone.

I think this is the idea among the people in the State of Illinois. I will illustrate it in this way. I don't know that it will solve it or even approach it. We have in the State of Illinois 12,000 or 13,000 miles of railroad. We have about a mile of road for each four miles and a half of territory. The question arises at once, haven't we put twice as much capital in the State of Illinois upon which we are all trying to pay interest, as there is any occasion for, and if so, hasn't a public duty been neglected in permitting that state of things to occur, and should it be allowed to occur in the future? There is another thought in the matter. Are the roads over-capitalized in the State? Are they worth $30,000 or $60,000 per mile? The people in the State of Illinois are paying interest on four times the amount of capital they ought to for transportation purposes inside the limits of the State of Illinois. Suppose that the property earns 10% on its actual investment, or 4% on its nominal investment Suppose other property earns a fraction of 1 or 2%. How long before this large investment eats up the rest? It is a question worth thinking about seriously, as to whether sooner or later it does not confiscate everything or mortgage everything. I do not express these as my own views, but as illustrating the question.

I have no doubt that there should be restrictions about paralleling lines and putting roads through territory that is properly occupied. Now what distance apart roads should be,—how close the territory can be covered, is a pretty hard question to answer. From having farming experience in my earlier days, I have this idea: A farmer won't make anything by living closer than four miles from a railroad. If he lives that far he will carry two loads a day. If he lives closer, he won't carry any more than that.

MR. BOURLAND:—Under the present management, doesn't that extra capitalization fall upon the stockholders more than on the general public? Now as long as the State has control of chargable rates,—as long as the State has its eye on the relations between the gross earnings and net earnings, then doesn't that extra capitalization come against the people who have put their money into that capitalization?

PRESIDENT:—I think it has resulted in that way in the history of the majority of roads.

MR. BOURLAND:—Don't you think that our Legislature has its eye on these facts to the extent that they are not allowing these largely watered stocks to fix the rates upon which they are paying for their freighting, for instance?

Adjourned. JOHN W. WESTON, Secretary.

CIVIL ENGINEERS' CLUB OF CLEVELAND.

NOVEMBER 11, 1890. Club met 8 p. m. Twenty-six members and five visitors present. The President and Vice-President being absent, Mr. W. R. Warner was chosen President pro tem.

The minutes of the last meeting were read and approved.

Mr. James Wallace Kelly and Mr. Frank Walter Wilson were elected active members.

Mr. Eisenmann reported the action of the committee at Chicago, on Oct. 14th, appointed to formulate plans for an International Congress of Engineers in connection with the World's Fair in 1893. The report was accepted, the committee continued and Mr. Wm. T. Blunt added to the committee.

The Executive Board recommended for election as active members Prof. Harry Fielding Reid, Prof. Arthur A. Skeels, Prof. Dayton C. Miller and Messrs. William ... Owen and Boswell H. St. John.

The President announced the reception by the Club of a number of publications, also a photograph of a large cut spur gear from the Walker Manufacturing Company. On motion it was voted to extend the Walker Manufacturing Company the thanks of the Club.

Mr. E. P. Roberts read a very interesting report of some of the things seen on "Visiting Day."

Prof. C. S. Howe read the following resolutions, and moved their adoption:

Resolved, That this Club express our gratification to the Cleveland City Forge and Iron Company, for their kindness in showing our members through their forge and buckle shop, and for numerous courtesies shown us by their officers.

Resolved, That the thanks of the Club are hereby tendered to the Otis Iron and Steel Company, (Lim.) for an invitation to inspect their works, and for numerous courtesies shown us on the occasion of our visit.

Resolved, That the Civil Engineers' Club of Cleveland express their acknowledgement for favors shown on the occasion of our recent visit to the works of the Brown Hoisting and Conveying Machine Company, and especially to Mr. Fayette Brown and Mr. Alex. Brown for personal attentions and many courtesies.

The resolutions were unanimously adopted.

Prof. Harry Fielding Reid, P. H. D., then gave a very interesting paper on "The Muir Glacier." Dr. Reid conducted an exploring party to Alaska this last summer, and he described many remarkable phenonema concerning this glacier, several of which have never before been observed in connection with glaciers, and some of which are exceedingly difficult to account for. At the conclusion of the paper there was an interesting discussion of several of the phenonema by a number of the members.

Motion was made to extend to Dr. Reid the thanks of the Club. Carried unanimously.

The President read a telegram of greeting from S. T. Wellman, J. F. Holloway. A. Swasey, J. W. Britton and Jos. Leon Gobeille, members of the Club, attending the convention of the American Society of Mechanical Engineers at Richmond, Va.

Adjourned. A. H. PORTER, Secretary.

ENGINEERS' CLUB OF ST. LOUIS.

335TH MEETING, NOV. 5, 1890. The Club met at 8.20 p. m., at the Elks' Club. President Nipher in the chair. 35 members and 3 visitors present. The minutes of the 334th meeting were read and approved. The Executive Committee reported the doings of its 9?th meeting.

Col. Meier reported for the committee appointed at the 333rd meeting to attend the meeting at Chicago in reference to a Congress of Engineering Societies to be held at Chicago during the World's Fair. A printed report of the meeting held at

Chicago, Oct. 14th and 15th was read and placed on file. It was moved and carried that the general plan as set forth in the report be approved, and that the Club take part as suggested, and appoint one delegate to act on the Committee on International Congress and Engineering Headquarters.

On motion Col. E. D. Meier was elected to act as delegate for the Club.

Prof. Nipher then gave the paper of the evening, "The Graphical Representation of the Output of the Steam Engine."

Professor Nipher discussed the output of the steam engine in terms of speed and pressure.

The indicated and brake horse power are each represented by a surface if speed and mean effective pressure be taken as the other variables. The surface representing indicated horse power is an hyperbolic paraboloid, and for all engines in which the volume swept through by the piston face in a stroke is the same, the surface will be common to all.

The brake horse power surface is the same surface projected along the pressure axis by an amount equal to the mean effective pressure in the friction card.

For an engine running at a fixed cut-off and without change in the throttle the relation between boiler pressure and mean effective pressure becomes determinate, and indicated and brake horse power can therefore be represented in terms of boiler pressure.

This gives two other surfaces, the positions of which will vary to and fro by the action of the throttle or a governor of varying cut-off.

Discussion followed by Messrs. Holman, Flad, Woodward, Engler, Meier, Gale and Ockerson.

Prof. Johnson being absent the paper on "Aerial Navigation" was laid over for the next meeting.

(Adjourned.) ARTHUR THACHER, Secretary.

336TH MEETING, November 19th, 1890. The Club met at 8:20 p. m. at the Elks' Club, President Nipher in the Chair, and twenty-nine members and six visitors present.

The minutes of the 335th meeting were read and approved.

Messrs. Meier, Holman and Potter were elected by ballot to serve as a committee to make nominations for officers of the Club for the ensuing year.

Prof. J. B. Johnson then read the paper of the evening, "The Natural Limitations of Aerial Navigation." Prof. Johnson said: "There are two natural and necessary resistances to be overcome, namely, gravity and the resistance of the atmosphere. If buoyancy is obtained by the use of hydrogen, by means of a spindle shaped vessel, the volume of this vessel is 28,000 cubic feet per ton of gross load, and the resistance in pounds to forward motion through the air is given by the equation $R = 0.00002\ D^2\ V^2$ where D is the greatest diameter in feet and V is the velocity in feet per second.

The gross horse power required to propel such a vessel at different speeds is—

$H.\ P. = 0.0015\ N^{2/3}\ V^3$ where N is the gross weight in tons and V is the velocity in miles per hour.

It is not possible, therefore, to ever attain to a velocity of over twenty-five or thirty miles per hour with balloons, and since the wind velocities 1,000 feet above the surface are more than three times those at the surface the failure of balloon navigation is a foregone conclusion.

To sustain one ton of load in the air by propeller wheels on vertical axes has been shown to require 60 horse power, and hence this is out of the question.

There remains only the flying devices called aero-planes on which to base one's hopes. When these are inclined upward in front at an angle of 1° 50', and propelled at a rate of twenty-five miles per hour, one ton can be carried at this speed by an expenditure of 6 horse power, and the power is proportional directly to the tonnage and to the speed. There would seem to be, however, no way of getting started or stopped or of maintaining the equilibrium. A momentary cessation of the application of the power is likely to prove disastrous. Even were the mechanical difficul-

es all solved in any one of these lines of development, the energy required and hence the cost of this kind of transport would forever exclude its use for any kind of commercial transport in competition with surface means. As a means of reconnoissance or of communication in time of war, it is even now a success for still weather but only national governments are warranted in expending capital in the development of aerial navigation with the expectation of an equivalent return."

Discussion followed by Messrs. Seddon, Johnson, Flad, Holman, Wheeler, Russell, Engler and Moore. Prof. Engler read a number of extracts from foreign publications showing what had been accomplished abroad in the direction of aerial navigation.

The paper for the next meeting was announced as follows: "Economic Dimensions of Settling Reservoirs," by J. A. Seddon.

Adjourned. ARTHUR THACHER, Secretary.

MONTANA SOCIETY OF CIVIL ENGINEERS.

N[illegible]MBER 15TH, 1890. The regular monthly meeting of the Society was held [illegible]e of Mr. E. H. Beckler, President; Second Vice President John Herron [illegible]pied the chair.

[illegible] were present Messrs. McRae, Foss, Kelley, Sizer, Haven and Keerl.

[illegible]es of the previous meeting were read and approved.

M[illegible] Henry J. Horn, Jr., of Helena, was declared elected to membership.

A [illegible]r was read from Mr. John W. Weston, Secretary, Western Society of [illegible], enclosing the "Report of the Convention held in Chicago, October 14, [illegible] to consider the establishment of an Engineering Headquarters and the [illegible] an International Engineering Congress, during the Worlds Columbian [illegible], 1893."

[illegible]ome discussion it was moved and carried that the recommendations and [illegible]plated, as set forth in said report be approved, and that a delegate be [illegible] to represent this Society on the General Permanent Committee. Motion [illegible] carried that Messrs. Herron and Keerl select a suitable delegate to serve [illegible]eral Permanent Committee, and to take whatever action relative to such [illegible]s in their judgment appears right.

[illegible] question of changing the meeting night of the Society, from the 3rd to the 1st or 2nd Saturday of the month, was discussed and on motion, carried, referred to the Committee on Revision of the Constitution and By-Laws.

Messrs. W. A. Haven, Walter S. Kelley and Finlay McRae were appointed a committee to nominate officers of the Society for the ensuing year.

Messrs. Walter S. Kelley and G. O. Foss of Helena, and Elliott H. Wilson of Butte were appointed a Committee of Arrangements for the Annual Meeting and Banquet of the Society, to be held January 17th next.

(Adjourned.) J. S. KEERL, Secretary.

INDEX DEPARTMENT.

ANNUAL SUMMARY.

It is proposed to furnish, in this department, as complete an Index as may be of current Engineering Literature of a fragmentary character. A short note will be appended to each title, intended to give sufficient information to enable the reader to decide whether or not it is worth his while to obtain or consult the paper itself. The Index will be mostly limited to society and magazine articles, and special engineering reports of general interest and value. It is printed in the monthly issues of the JOURNAL, *on but one side of the paper, so that the titles may be cut out and pasted on cards or in a book, and is here collected with additional cross references.*

LIST OF PERIODICALS INDEXED.

American Architect (Am. Arch.), weekly, Ticknor & Co., 211 Tremont street, Boston, Mass.; single copy, 15 cents.

American Engineer (Am. Engr.), weekly, Gaff Building, Chicago, Ill.; per year, $2; single copy, 5 cents.

American Machinist (Am. Mach.), weekly, 93 Fulton street, New York; per year, $2.50; single copy, 5 cents.

American Manufacturer and Iron World (Am. Mfr.), weekly, Pittsburgh, Pa.; per year, $4; single copy, 10 cents.

Electrical Review (Elec. Rev.), weekly, 22 Paternoster Row, London, E. C.; per year, 21s. 6d.; single copy, 4d.

Engineering Record (Eng. Record), weekly, 277 Pearl street, New York, per year, $4; single copy, 12 cents.

Engineering News (Eng. News), weekly, Tribune Building, New York; per year, $5; single copy, 12 cents.

Engineering and Mining Journal (E. & M. Jour.), weekly, 27 Park Place, New York; per year, $1; single copy, 10 cents.

Engineering (Lon. Eng.), weekly, London, England; per year, $10; single copy, 25 cents.

Indian Engineering (Ind. Eng.), weekly, Calcutta, India; 78s. per year; single copy, 8 Annas.

Journal of the Franklin Institute (Jour. Fran. Inst.), monthly, Franklin Institute, Philadelphia, Pa.; per year, $5; single copy, 50 cents.

Journal of the Association of Engineering Societies (Jour. Assn. Eng. Soc.), monthly, 78 La Salle street, Chicago; per year, $3; single copy, 30 cents.

Journal of the Society of Arts (Jour. Soc. Arts), weekly, London, England; single copy, 6d.

Mechanics (Mechanics), monthly, 907 Arch Street, Philadelphia, Pa.; per year, $1; single copy, 10 cents.

Power (Power), monthly, 113 Liberty Street, New York; per year, $1; single copy, 10 cents.

Proceedings American Institute of Mining Engineers (Proc. A. I. M. E.), 13 Burling Slip, New York; per year, $5.

Proceedings of the United States Naval Institute (Proc. U. S. N. I.), quarterly, United States Naval Institute, Annapolis, Md.; per year, $3.50; single copy, $1.

Railroad and Engineering Journal (R. R. & Eng. Jour.), monthly, 45 Broadway, New York; per year, $3; single copy, 25 cents.

Railroad Gazette (R. R. Gaz.), weekly, 73 Broadway, New York; per year, $4.20; single copies, 10 cents.

Railway Review (Ry. Rev.), weekly, The Rookery, Chicago, Ill.; per year, $4.

Scientific American Supplement (Sci. Am. Sup.), weekly, 361 Broadway, New York; per year, $5; single copy, 10 cents.

Scientific American (Sci. Am.), weekly, 361 Broadway, N. Y., per year, $3.

Street Railway Journal (St. Ry. Journ.), monthly, 113 Liberty street, New York; per year, $2.

The Electrical Engineer (Elec. Engr.), monthly, 11 Wall street, New York; per per year, $3; single copy, 30 cents.

The Electrical World (Elec. World), weekly, 177 Times building, New York; per year, $3; single copy, 10 cents.

The Engineer (Lond. Engineer), weekly, London, England; yer year, $10; single copy, 25 cents.

The Railway Master Mechanic (Mast. Mech.), monthly, "The Rookery," Chicago, Ill.; per year, $1; single copy, 10 cents.

The Mechanical World (Mech. World), weekly, Manchester, England; per year, 8s. 8d.; single copy, 1 penny.

The Street Railway Gazette (St. Ry. Gaz.), monthly, 8 Lakeside Building, Chicago; per year, $2; single copy, 25 cents.

Transactions American Society of Civil Engineers (Trans. A. S. C. E.), 127 East Twenty-third street, New York; per year, $10.

Transactions Canadian Society of Civil Engineers (Trans. Can. Soc. C. E.), Sec'y., McGill University, Montreal.

Transactions of the Technical Society of the Pacific Coast (Trans. Tech. Soc. Pac. C.) Rooms 14-15, 408 California street, San Francisco, Cal.

Abt Rack Rail System. See Railway, *Manitou & Pikes Peak*.

Accidents. See Railroad Accidents.

Accumulators *in Electric Lighting*. An excellent article, fully illustrated, read as a paper before the Am. Inst. of Electrical Engrs. By George R. Prescott, Jr. Describes methods of using and regulating accumulators in various classes of electric lighting work. *Elec. Eng.*, November, 1889.

Address *by Mr. Wm. P. Shinn*, President A. S. C. E., at the Cresson meeting. *Eng. News*, July 5, 1890, pp. 9-11.

——. *of W. R. Warner, President C. E. Club, Cleveland*, at the annual banquet, March 29, 1890. *Jour. Assn. Eng. Soc.*, July, 1890, pp. 353-6.

——. *on Retiring from Presidency of the Western Society of Engineers.* By Mr. E. L. Corthell. *Jour. Assn. Eng. Soc.*, May, 1890, pp. 209-233.

——. *on Retiring from the Presidency of the St. Louis Engineers' Club.* By Col. E. D. Meier. *Jour. Assn. Eng. Soc.*, Feb., 1890, Vol. IX., pp. 43-50.

Aerial Navigation. An interesting illustrated lecture delivered by Mr. O. Chanute, C. E., at Cornell Univ. *R. R. & Eng. Jour.*, July, 1890, *et seq.* pp. 316-8.

——. *The Problem of Air Navigation.* A popular article by Prof. R. H. Thurston, discussing the history of the problem and experiments and observations upon birds. *The Forum*, Vol. VIII., 1889, pp. 542-54.

Aeronautics. *Vacuum vs. Inflation.* A paper by Dr. A. de Bausset, Boston, Mass. *Am. Engr.*, Nov. 29, 1890, pp. 238-9. *et seq.*

Allen, Horatio. A brief account of the life and work of the late Horatio Allen, one of the most prominent of American engineers. *Eng. News*, Jan. 11, 1890, p. 29

Aluminum *and Other metals Compared* and *Aluminum in Wrought Iron and Steel Castings.* Two valuable papers by Mr. W. J. Keep, read at the Washington meeting of the A. I. M. E., Feb., 1890. Tables and diagrams, pp. 37 and 24. *Trans. A. I. M. E.* An abstract of the latter paper is in *E. & M. Jour.*, Aug. 30, 1890, pp. 345-7.

——. *Grabau's Method of Making. Annales des Mines*, Vol XVI, p. 534. The Heroult process is described in *Le Genie Civil*, May, 1890. Abstracts of both of these papers are in *Proc. Inst. C. E.*, Vol. CI, 1890, p. 379. Former paper in *E. & M. Jour.*, Aug. 16, 1890, pp. 191-2.

——. *The Heroult Process of Smelting Aluminum Alloys.* A short paper by Mr. F. P. Depew, read at the Washington meeting of the A. I. M. E., Feb., 1890. *Trans. A. I. Min. Engrs.*

——. *The Manufacture of.* An illustrated description of the various processes, and a table giving the results of tests. Reprinted from *Le Genie Civil*, *Sci. Am. Sup.*, No. 753, June 7, 1890, pp. 12023-5.

——. *The Production of the Alloys of Aluminum and Silicon in the Electric Furnace* (Cowles' process). A paper before Sec. B. British Association, by J. H. J. Dagger F. C. S., F. Q. C., tracing the development of the industry from its inception, and giving concise descriptions of the new Cowles furnace and its operation, also giving a statement of the principal properties of aluminum alloys, as strength, elasticity, elongation, etc. *Sci. Am. Sup.*, Nov. 30, 1889.

——. *The Properties of Aluminum.* With some Information Relating to the Metal. An article by A. E. Hunt, J. W. Langley, and C. M. Hall, giving much valuable information. Chemical analyses of metals, as made by several companies. Specific gravity, strength, and other physical properties are fully given. *Am. Manfr.*, Feb. 21, 1890, p. 8. *et seq.*, *Eng News*, Feb. 22, 1890, Vol. XXIII., p. 183. *Iron*, July 18, 1890, *et seq.*

——. *Transverse Strength of Aluminum.* Record of transverse tests made by A. E. Hunt. Good deflection and permanent set are given for two tests. *Eng. News*. March 15, 1890, Vol. XXIII., p. 250.

Aluminum Bronze *and Brass as a Suitable Material for Propellers.* A paper read by Eugene H. Cowles at meeting of the American Institute of Mining Engineers,

some bridge, with description condensed from the specifications. *R. R. Gaz.*, Aug. 15, 1890, p. 565.

——. *Stone, Elyria, O.* This fine highway arch is briefly described and illustrated. Clear span 150 feet. Rise 27 feet. *Eng. News.*, May 31, June 21, 1890, pp. 506-579.

Arch Bridge. *Minneapolis Steel Arch Bridge.* Brief and well illustrated description of main features of this structure. *Eng. & Build. Rec.*, May 10, 1890, p. 358.

——. *Reconstruction Connemaugh Arch Bridge.* Illustration showing principal dimensions and details of new Connemaugh viaduct, with brief notice. *Eng. News.*, March 29, 1890, Vol. XXIII., p. 291.

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